

AN ENERGY MANAGEMENT TRAINING STUDY

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PREFACE

This study lays the foundation for profit improving, cost effective energy management programs. Faced with rising energy costs and fuel shortages, many industrial leaders are emphasizing the growing need for cost reduction through energy management. However, many managers are not adequately informed of potential energy saving techniques to support an effective energy management program. This study, consisting of an energy manual and an interactive computer program, sensitizes people to the present energy situation, discusses the design and implementation of energy management programs and analyzes four major energy saving techniques--power factor improvement, demand control, temperature control, and ventilation control.

I would like to express my sincere appreciation to my major advisor, Wayne C. Turner, whose guidance throughout my residency at Oklahoma State University has been invaluable. In particular, for being a friend as well as a professor.

Finally, the deepest appreciation is expressed to my wife, Sandra, without whose encouragement, understanding, and hard work this study would doubtfully have been completed, and to my mom and dad who gave me the opportunity to attend this establishment.

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INTRODUCTION

Problem Statement

Energy costs are skyrocketing with no immediate relief in sight. In fact, some predict fuel costs to increase three to ten percent above inflation, meaning energy costs are increasing both absolutely and relatively.¹ To further illustrate the severity of the present energy situation and to demonstrate the necessity of dynamic energy management programs, domestic oil production peaked in 1970 and U.S. gas production in 1974. However, this does not mean the U.S. will not enjoy brief minor subpeaks, (e.g., the Alaskan field), but it does indicate the total U.S. gas and oil production is decreasing. Another example, in 1970 the U.S. imported just 23 percent of her petroleum needs; recently, however, this figure has jumped above 60 percent on several occasions. Therefore, there is no question that energy costs are and will continue to drastically increase and that future supplies are likely to be undependable.

Industry, consuming about 40 percent of the total U.S. energy supply, is the most adversely affected by the energy "crisis". Many manufacturers are, therefore, interested in reducing energy costs; but, the technology, though not new, is not widespread or applicable to all industrial situations. Energy problems have no common solution, as the problems confronting a small to medium size industry are different from those faced by larger manufacturers. Similarly, problems

¹Statistics used can be found in the bibliography especially (10), (26), (27), (42), and (43).

vary between industrial classifications. For example, many of the solutions for the printing industry will be different from those tailored to a small metal manufacturing company.

An organized effort by industry in the U.S. is needed to effectively combat the growing energy problem. A study, analyzing present, cost effective energy management ideas, effective over a wide variety of industrial situations, is essential to the success of this management effort. The problem then is the lack of basic knowledge throughout industry on how to cope with the energy crisis. This vacuum is particularly strong in small to medium sized concerns.

Objective of Study

The major objective of this study is to develop an energy management training scheme; consisting of a training manual, analyzing the elements of an effective energy management program and an interactive computer simulation of potential energy management opportunities. Specifically, the manual is divided into three modules--the energy management program and two energy management opportunity areas, electricity usage and heating, ventilation and air conditioning control. The causes of energy problems, their impact upon an industrial facility and potential improvement techniques for various situations will be analyzed.

The interactive computer simulation, integrated with each energy management opportunity module, aids the user in understanding the economic justification of potential energy saving ideas. Programmed flexibility of the computer simulation, allows the user to enter specific data for modeling a variety of manufacturing facilities and environmental surroundings.

Guideline objectives of this study are to sensitize people to the current energy situation and to train, those interested, in current energy management techniques. A major thrust of this effort is to provide an experimental teaching medium for courses in Industrial Energy Management in the School of Industrial Engineering and Management at Oklahoma State University. The workbook, analyzing potential energy problems, will familiarize students with "real world" industrial situations and the procedures for economic analysis will demonstrate methods for project selection. Students will also, through use of the computer, gain a greater appreciation for interactive computer programming.

Similarly, this study will aid small to medium size industry across the state of Oklahoma in the selection of cost effective energy management ideas. Through the Oklahoma Industrial Energy Management Program, which is working closely with companies statewide, many of Oklahoma's businesses will utilize the computer simulation to help evaluate proposed energy saving ideas. Finally, the study will supplement the Industrial Energy Management Program material, adding numerous references, illustrating current energy saving techniques.

Motivation for Study

American industry is responding to the challenge presented by the current energy situation, partially illustrated by the fact that industrial consumption relatively has dropped, so that, residential consumption is now higher than industrial energy demands. This can be attributed to a growing interest, by all larger manufacturing concerns. However, many interested facility managers are not adequately informed about energy saving techniques, to implement cost effective energy

management opportunities. This study is designed to aid these managers in the understanding and selection of cost effective energy saving ideas. A portion of the study, an interactive computer program, will perform some of the calculations necessary to evaluate the cost effectiveness of proposed ideas; thus helping managers rank prospective management improvements. The Oklahoma Industrial Energy Management Program, based at Oklahoma State University, will be the distribution center for this effort.

In the academic atmosphere, recent attention has focused on current energy management techniques. This study will provide a medium for students and instructors to experiment with various industrial situations, gaining a greater sensitivity and knowledge of the energy picture.

REPORT STRUCTURE .

Training Modules

The training manual is organized into three basic modules--the energy management program, electricity usage, and heating, ventilation and air conditioning control. The energy management program module discusses the sequence of steps to design and properly implement an effective energy management program. Cost effective energy management opportunities are presented and four, designed for growing programs, are highlighted.²

The second training module, electricity usage, describes various industrial utility rate structures and emphasizes each of the major components affecting consumers. First, power factor is defined, its causes analyzed and several methods of power factor improvement are discussed with an economic analysis of capacitor placement. Second, the aspects of demand charging, the costs, impacts on industrial facilities, and potential savings are presented. A computer simulation of two identical facilities, one with demand control and one that is uncontrolled, illustrates the potential savings available.

Heating, ventilation and air conditioning control, the third module, demonstrates the substantial savings available through thermostat control and reduced ventilation requirements. A number of energy management techniques, all requiring low capital expenditures, are analyzed under the subsections--temperature control and ventilation control.

The training manual is organized in an accepted formal Master's Report structure. However, the three modules have been prepared to

²The modular construction of the training program allows for additional ideas to be easily added in future research.

stand alone also, for use in conferences, workshops, classrooms, etc. At the interface between the modules and the introductory material, there is a change in writing styles to correspond with the anticipated audience.

There are countless proven cost effective energy saving ideas, many of which require capital expenditures and engineering design with paybacks often less than three years. Due simply to the vast scope, other energy saving ideas will not be discussed in this study as this training manual will emphasize initial, low cost, quick pay-back energy management ideas. The bibliography contains many references designed for specific energy saving techniques, including insulation sizing and placement, lighting, boiler management, steam and hot water usage, and applications of waste heat recovery.

Computer Program Interface

The computer program, the "Energy Simulator", plays an integral part in this energy management study. Within each energy saving module, the computer will execute an example problem and/or allow the user to model a particular situation using case specific data. The user should first execute the example problem on the computer, then if there are questions, consult the example section in the energy manual. The program, designed to prompt the user when data needed, has the following energy management subjects simulated--Power Factor Analysis, Demand Control, Temperature Control, and Ventilation Control.

The program structure, written in FORTRAN, has a separate subroutine for each energy management module, thus, allowing easy expansion in the future. The first subroutine, Power Factor Analysis, calculates the present power factor penalty costs. The computer simulation, il-

illustrating capacitor implementation, calculates the required sizes of capacitors and their corresponding installation costs. Using these costs and the present penalty costs the payback³ is determined; however, this routine is not an optimum seeking procedure, but, the user can simulate several models and compare payback periods.

The demand control subprogram simulates, using two uniform distributions, a predetermined number of electric motors operating during an eight hour work period. A random number generator assures that each motor has an approximately equal chance of operating during any one minute interval. Initially, the motors operate unconstrained and the highest power demand during the day is determined. Using this value and based upon an Oklahoma utility rate structure for medium size industry, the monthly utility bill is calculated. For comparison, the motors are simulated under the same conditions except a demand limit is set. That is, motors are turned off as the power demand approaches the set demand limit. The highest power demand encountered is again determined and the associated utility bill calculated. The two monthly utility statements, when compared, show a substantial energy and monetary savings potential when using a demand control device.

Substantial savings, by merely controlling thermostat levels can be realized by industrial facilities, as illustrated by the temperature control subroutine. By adhering to recommended standards industry can continue productive processes while reaping savings on its cooling and heating utility bills. The input data allows the user to control various parameters including temperature changes, hours of adjustment,

³Payback is used instead of internal rate of return because of its general acceptance in all levels of manufacturing.

and energy requirements of heating and cooling systems.

The ventilation control subprogram illustrates two potential savings--reduced energy requirements for conditioning outside make up air and reduced ventilation fan operating time. The program calculates potential savings as well as approximating potential horsepower reduction in ventilation units. The system design is relatively simple and the savings are impressive; however, the engineer must work closely with accepted OSHA ventilation standards.

FACILITIES MODEL DESCRIPTION

This section will not describe in detail the energy usage of industrial facilities. It will set the foundation for energy management, discussing some common characteristics and problems encountered by many facilities.

The energy problems encountered by small to medium size industry are different from those problems confronting larger manufacturing company. In Oklahoma, many of the larger facilities, feeling the impact of the energy situation, have ongoing energy management programs. However, many smaller manufacturers are not aware of their energy costs or do not feel present costs are large enough to warrant attention. As energy costs continue to escalate, energy management programs are and will continue to be obvious effective methods of cost reduction. Proven first year savings, requiring minimum capital, range from five to fifteen percent, as well as, provide related improvements, such as, better quality products, increased environmental standards, etc.

Oklahoma industry, like all industry, cannot be classified into "typical" facilities; however, there are building and operating characteristics common to many. If the plant is cooled, the air is conditioned usually by thermostatically controlled roof units. Space heating is often performed by forced air radiation units and/or direct fired gas heaters and the roofs of most manufacturing plants are pierced with ventilation fans, many stuck open or poorly controlled. The insulation quality is medium, meeting established standards ten years ago and the lighting is usually fluorescent or mercury vapor in high bay areas. Most industrial facilities are billed on a rate structure penalizing

poor power factors and high power demands. Energy saving potentials in such facilities are substantial.

The first step to energy cost reductions is to establish an energy management program. A total commitment, from top management down to individual floor workers is absolutely necessary to insure success. Eventual program savings of 30 percent are common with isolated instances as high as 60 percent savings.

ENERGY MANAGEMENT PROGRAM

Program Objectives

A portion of the American Institute of Industrial Engineer's formal definition of industrial engineering reads, "Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of men, materials, equipment, and energy."

The word "energy", recently added, emphasizes the concern with the energy situation and illustrates an eagerness and an obligation to confront the problem. The United States Department of Energy recently said, "The days of simply worrying about material and labor are over. Energy has become the third dimension."

Energy management is defined as the judicious and effective use of energy towards the accomplishment of some objective(s), or more simply, it is utilizing energy wisely to improve the company's competitive position. The four broad objectives of an energy management program are, to maximize profits, to conserve energy, to prepare contingency plans in the event of fuel curtailments and to plan fuel storage and potential security and stand by requirements.

Industry is primarily concerned with cost effective, energy saving ideas; therefore, conserving energy, though a welcomed by-product, is not the primary objective. Competition for available capital is high, therefore, ideas must economically justify themselves before implementation.

Program Design and Implementation

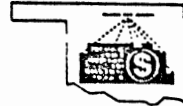
Initial design is the critical phase of an energy management program, as top management must show their committment to insure its success.

Management has available numerous ways to demonstrate this dedication. Plant meetings and newsletters, involving all facility personnel, discussing current and proposed projects are excellent ways of initiating energy management programs. Rewarding cost effective ideas will often motivate employees to investigate potential ideas related to their activities and most importantly, management must fund cost effective energy saving ideas, as nothing will damage a program worse than overlooking proven cost effective proposals.

Management must appoint as the energy coordinator, a dynamic individual, with full responsibility for the program. This person should be a strong leader and a good manager. In large companies the energy coordinator should be a full time position; however, in smaller industries the coordinator may be the plant manager and share two responsibilities. Depending on the complexity of the energy program, the energy manager may select a committee to help implement the program. Possible committee members include, industrial engineers, plant engineers, maintenance personnel, floor workers, etc. Most importantly, the committee must have dynamic creative people, willing to work. The more people involved with the program, inputting their ideas, the more likely the program is to succeed.

The energy management program must develop a uniform method of accounting energy costs. The Oklahoma Industrial Energy Management Program, (OIEMP), defines this procedure as a "gross audit"; its purpose being to determine how much money is being spent on energy and to determine what energy sources are being used. Figure I , shows an example gross audit form, developed by the OIEMP, being used in businesses across Oklahoma. As illustrated, under each energy source--electricity,

Date of Last Audit _____



Form A

Year Month	Units of Production (1)	KWH (2)	Electricity				Natural Gas			Gasoline			Other Fuels			Monthly Totals			Comments	
			KW Demand		Power Factor (5)	Total Cost (6)	(2)x A BTU/Mo. (7)	KCF (8)	Total Cost (9)	(7)x B BTU/Mo. (10)	Gallon (11)	Cost (12)	(10)x C BTU/Mo. (13)	Type:	Cost (15)	#Units x BTU/Unit (16)	(6)+(9)+ (12)+(15) Cost (17)	(7)+(10)+ (13)+(16) BTU (18)		(18)÷(1) BTU/Unit (19)
			Actual (3)	Billed (4)										#Units (gal, ft³, ton, etc.) Specify (14)						
TOTAL																				
Conversion factors		A = 10,000 BTU/KWH								B = 1,000,000 BTU/KCF			C = 130,000 BTU/GAL			D = _____ BTU/Unit Specify				

Figure I

natural gas, and gasoline--a more detailed analysis is necessary to determine the total energy costs including any related penalties. Within each source division, the energy units, kwh, kcf, etc., are converted to BTU's to facilitate comparisons of energy sources. Finally, an energy utilization index, (EUI) a ratio of energy consumed per unit of end product, is determined for each billing period. The EUI measures the effectiveness of an energy management program as the BTU's consumed decreases while the units of production, such as, tons of steel, number of tires, square footage of plant area, etc., remains relatively constant. (Comparing energy costs, because they are constantly rising, will not give a fair evaluation of an energy management program.) Therefore, the monthly EUI can be used to monitor the progress of the energy management program, since the EUI will reflect the decreased energy necessary to produce the final product.

An effective energy management program will establish goals and share them with all company employees as, energy savings ideas, from all levels of personnel, should be given attention. An abundance of ideas are also available in numerous publications by both government and private organizations. Pages of energy saving ideas have been published for management programs to use as guidelines for selection of ideas for their particular situations. Conferences and workshops, presented regularly around the country, are also excellent sources of information.

After the program has yielded savings and employee interest has grown, a more detailed analysis of the facility energy consumers is needed. The energy usage of individual consumers, machinery, HVAC

systems, lighting, etc., should be calculated to help pinpoint potential energy management opportunities. More information concerning audit procedures can be obtained in (26), (42), (43), and (44).

Initial energy management programs should concentrate on quick payback energy saving ideas, as substantial savings can be realized by numerous no-cost, low-cost management opportunities. This study will now analyze four such ideas--power factor improvement, demand control, temperature control, and ventilation control.

ELECTRICITY USAGE

Utility Rate Structures

Industrial rate structures generally include schemes for penalizing poor power factors and high electrical power demands, as well as, conventional consumption charges and various fuel cost adjustments. Though often overlooked, power factor penalties and demand charges can be substantial amounts of an industrial electricity bill. Briefly, a power factor is a measure of how efficiently a consumer is using his electricity. Demand is defined as the instantaneous charge on the utility for electric power. (See Appendix B for typical Oklahoma electricity rate structures.) Utility rate structures will vary from one power company to the next; however, the ideas presented in this module are applicable to all industry.

Consumption charges reflect the total electrical requirements of a billing period. Many utilities scale the costs of electricity according to a monthly usage, Table I; as the electricity requirements increase, the corresponding costs per kwh decrease. Other utility companies offer rate structures to large electrical consumers allowing them the option of a demand clause basis, where the costs per kwh are generally smaller than conventional, but an additional demand penalty charge is included.

First	15000 kwh per month @ 2.968¢ per kwh
Next	17500 kwh per month @ 2.378¢ per kwh
Next	37500 kwh per month @ 1.897¢ per kwh
All additional	kwh per month @ 1.640¢ per kwh

Electricity Pricing Profile

Table I

Power companies, in isolated regions of the U.S., are billing on "time of day structures", where the costs of electricity are higher during the working day but offer substantial savings during night periods. These clauses emphasize the need to industry for well scheduled power usage, thus, lowering both consumption and power demand profiles.

High electrical power demands are often penalized by utility companies. Different charging seasons, where the penalty costs vary are imposed by most rate structures. For one utility in Oklahoma, the On-Peak Season is from June through October and the demand charge is \$2.20 per kw; whereas, during the Off-Peak Season, November through May, the charged amount is only \$1.55 per kw. The exact billing regulations, costs, demand limits, measurement periods, etc. vary; however, demand charges are a substantial portion of the energy costs and therefore represent a substantial energy management savings potential.

Power factor penalties represent another large portion of an electricity bill. Power factors below established standards, usually near 0.80, are heavily penalized, while power factors greater than 0.80 are often rewarded, as illustrated by the following Oklahoma scheme.

$$\text{ENERGY COST} = \text{BILLED DEMAND} \times \left[0.80 / \text{PRESENT POWER FACTOR} \right] \times \text{COST}$$

where cost ranges from \$2.20 to \$1.55 per kw. In this scheme, the power factor charge is based on the demand charge; however, some billing structures have specific rates for corresponding levels of power factor. Details of power factor penalizing will vary but improvement techniques are common throughout industry.

Power Factor Analysis

Power factor improvement is not difficult, with several methods available, and widely used in industry. Its improvement can yield substantial monetary savings as well as increasing plant capacity and motor performance. First, the engineer must investigate the causes of poor power factors, then examine methods for its improvement.

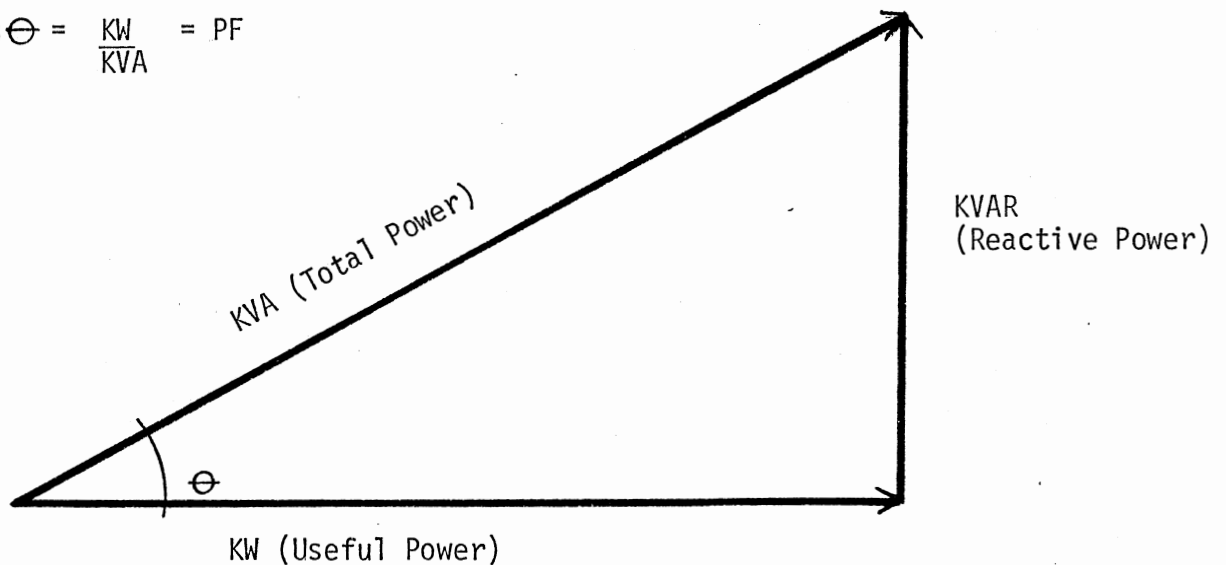
Definition of Power Factor

Many industrial facilities are penalized for operating with poor power factors. Again, power factor is how efficiently a consumer uses his electrical energy. Electrical power is represented by a mathematical relationship of three components, Figure II, KVA, KW, and KVAR; where KVA is the product of the measured voltage and amperage; KW is the amount of "useful" power available at the motor; and KVAR is the component comprising the magnetic power required by reactive loads. Poor power factors are penalized because utility companies must supply this KVAR component thereby, decreasing the line capacity for transmission of useful power. As the KVAR component decreases, the measured and actual available power, approach one another. Therefore, when the KVAR is equal to zero, a power factor of unity, the measured KVA is equal to the "useful power," KW.

Causes of Poor Power Factors

Poor power factors, for example, below 0.80, are usually caused by induction motors, fluorescent lamps, air conditioning units, welders, and other inductive devices. Perhaps, the most common source is operating electric motors at partial loads, as motors do not operate at 60 percent load as efficiently as at 85 or 100 percent load. This is

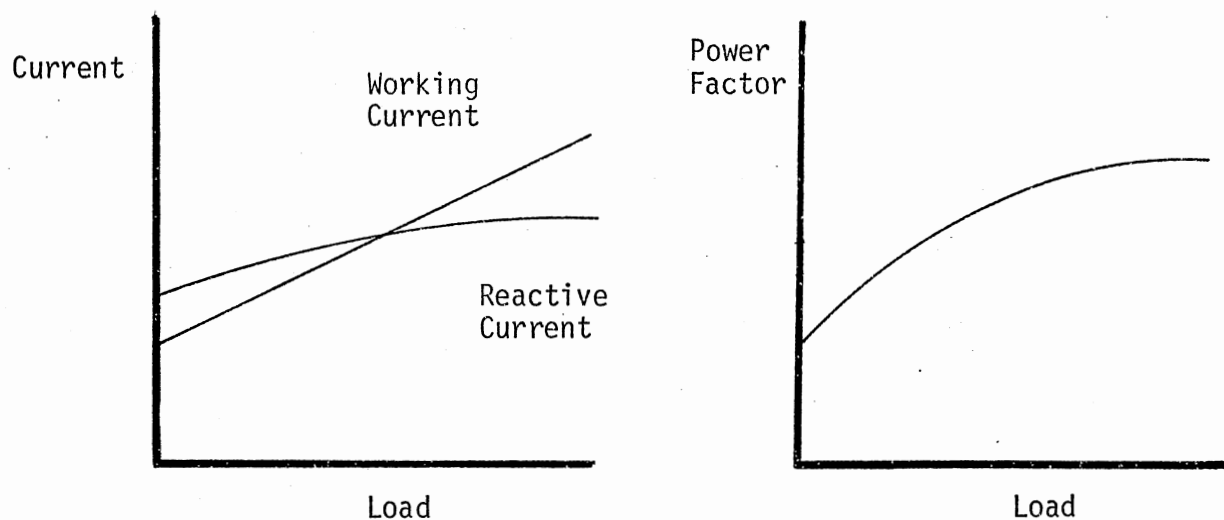
$$\cos \Theta = \frac{KW}{KVA} = PF$$



Electricity Component Relationship
Figure II

demonstrated in Figure III. Many facilities, when designing electric motor systems, oversize motors as a safety factor; however, this practice is not life cost effective, because of increased consumption and power factor penalty charges.

The effects of poor power factors are varied, including overloaded electrical distribution systems, reduced voltage levels, reduced lighting outputs, sluggish motor operations and most importantly, substantial penalty costs. Penalty costs differ, depending on the utility rate structure; for example, they are sometimes based on the "demand charge" as shown earlier, while other utilities bill according to the total KVAR supplied, or according to schedules based on KW/KVA, a higher ratio would lead to a lower per unit charge.



Power Factor of Induction Motors
Figure III

Power Factor Improvement

There are several methods of correcting poor power factors, two of which are properly sizing motors to load requirements and installing capacitors to supply necessary magnetizing current. New facilities should particularly concern themselves with properly sized equipment, synchronous motors, synchronous condensers, energy efficient motors, etc.; whereas, existing facilities should investigate the potential of capacitor implementation. Although, synchronous motors and condensers may be used in retrofit applications, this study will focus on the proven cost effectiveness of capacitors.

A capacitor, which receives and stores electrical charges, can supply the magnetizing current required by an electric motor. As

the capacitor supplies the required KVAR, the feeder line behind the placement, freed of its KVAR requirements, increases in capacity. Therefore, the nearer the capacitor placement to the problem source, the more the electrical system will be cleared of its magnetizing requirements.

There are primarily three basic positions for placement of capacitors--on the line side of the electric meter, on the main feeder lines within the facility, and on individual motors. The latter two will be emphasized in this study. Placing capacitors on individual motors is perhaps the most expensive of the three methods, primarily due to larger capital requirements and increased installations costs. However, it does release the electrical distribution system of its KVAR requirements, thus increasing plant power capacity. Therefore, when plant expansion is a future possibility and increased electrical capacity is required, capacitor placement on individual motors should be considered. (Motors have an upper capacitance limit. When encountered, the largest possible size capacitor should be placed on the motor and the remainder of the KVAR requirements supplied by capacitors on the feeder lines.)

As mentioned previously, capacitors may be placed on main feeder lines where there are several advantages. First, the implementation costs are usually less and second, the overall power factor per KVAR capacity is improved more than with individual motor placement. The disadvantage is, however, the plant power capacity is not greatly increased. This study will analyze capacitor installation on facility feeder lines; but, calculations for individual motor placement are very similar.

Capacitor Sizing

Capacitor sizing is very critical as, too large or too small of capacitor ratings will result in continued poor power factors. Sizing capacitors is relatively easy if the following design procedure is closely followed.

First, the voltage and amperage must be measured and the present power factor determined. (Many times the utility company will supply this information.)

Step 1: Calculate the total power, KVA

$$\text{KVA} = \text{VOLTAGE} / 1000 \times \text{AMPERAGE}$$

Step 2: Calculate the available power, KW

$$\text{KW} = \text{KVA} \times \text{PRESENT POWER FACTOR}$$

or if nameplate data is available

$$= \text{HP} \times .746 \text{ KW/HP}$$

Step 3: Calculate the present magnetizing current, KVAR

$$\text{KVAR} = \sqrt{(\text{KVA})^2 - (\text{KW})^2}$$

Step 4: Knowing the desired power factor and keeping the useful power, KW, constant, calculate the desired KVA

$$\text{KVA}' = \text{KW} / \text{DESIRED POWER FACTOR}$$

Step 5: Calculate the desired KVAR

$$\text{KVAR}' = \sqrt{(\text{KVA}')^2 - (\text{KW})^2}$$

Step 6: Calculate the necessary KVAR to be supplied by capacitors

$$\text{KVAR}_n = \text{KVAR} - \text{KVAR}'$$

At the present time, the cost of capacitors is approximately \$18.50 per KVAR, according to a major Oklahoma utility company.

Computer Application

The following example is simulated on the computer. STOP - try it, get comfortable with the program. If you still have questions, then review the example. The program will model most situations but has a rigid procedure that must be followed.

Step 1: After reaching the *READY* mode, enter
EXEC ENERGY.

Step 2: From this point, the computer will prompt the user as necessary. Enter values, if asked, after the computer places a ?. Important!! When entering decimal values, place a zero before the decimal point (e.g. 0.8 not just .8) To use the power factor routine, enter a 1 when appropriate.

Power Factor Analysis Example

A medium size metal fabricating plant in Perry, Oklahoma utilizes a large number of overly sized induction motors and welders. Lighting is furnished by several hundred eight foot fluorescent lights. At the present time, the facility is paying a penalty for bad power factor, that is, below 0.80. There are no long range plans for plant expansion; therefore, management is considering capacitor placement on the main feeder line.

Data

Average Billed Demand	200 KW
Penalty Cost	\$2.00/KW-month
Voltage	440 volts
Amperage	900 amps
Present Power Factor	0.5
Desired Power Factor	0.8
Electrical Phase	3

Procedure:

First, determine the penalty cost

$$\begin{aligned}
 \text{PENALTY COST} &= (\text{BILLED DEMAND} \times 0.8 / \text{PRESENT POWER FACTOR}) \times \text{COST}^4 \\
 &= (200\text{KW} \times 0.8 / 0.5) \times \$2.00/\text{KW/month} \\
 &= \$640.00/\text{month}
 \end{aligned}$$

Now calculate current conditions

$$\begin{aligned}
 \text{KVA} &= (440\text{volts} \times \text{KV} / 1000\text{v} \times 900 \text{ amps}) \times \sqrt{3} \\
 &= 381 \text{ KVA}
 \end{aligned}$$

$$\begin{aligned}
 \text{KW} &= 381 \times 0.5 \\
 &= 190.5 \text{ KW}
 \end{aligned}$$

$$\begin{aligned}
 \text{KVAR} &= \sqrt{(381)^2 - (190.5)^2} \\
 &= 330 \text{ KVAR}
 \end{aligned}$$

Using the desired power factor, 0.80 (just an example) calculate desired conditions.

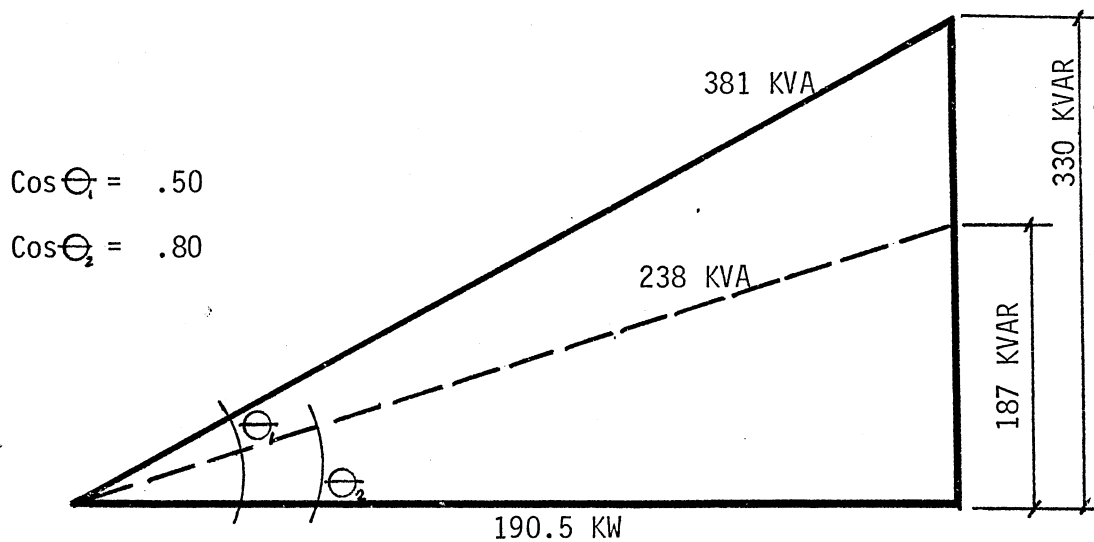
⁴Rating scheme of a major Oklahoma utility

$$\begin{aligned} \text{KVA}' &= 190.5 / 0.8 \\ &= 238 \text{ KVA} \end{aligned}$$

$$\begin{aligned} \text{KVAR}' &= \sqrt{(238)^2 - (190.5)^2} \\ &= 143 \end{aligned}$$

Finally, calculate the necessary KVAR

$$\begin{aligned} \text{KVAR}_n &= 330 - 143 \\ &= 187 \text{ KVAR} \end{aligned}$$



KVAR Reduction Relationship

Figure IV

The new monthly cost will be

$$\begin{aligned} \text{COST} &= (200 \text{ KW} \times 0.8 / 0.8) \times \$200.00 / \text{KW/month} \\ &= \$400.00 / \text{month} \end{aligned}$$

The capacitor cost will be

$$\begin{aligned} \text{COST} &= 187 \text{ KVAR} \times \$18.50 / \text{KVAR} \\ &= \$3459.50 \end{aligned}$$

The undiscounted payback will be

$$\begin{aligned}\text{PAYBACK} &= \$3459.50 / (\$640 - \$400) \\ &= 14.41 \text{ months}\end{aligned}$$

Capacitors are useful in both increasing plant capacity and in reducing utility bills. Each situation will be different, but should warrant serious consideration.

Though substantial savings can be realized through power factor improvement, even greater potential may lie in controlling power demands. As in the previously discussed rate structure, potential savings may be two fold--both in power factor and demand penalty cost avoidance.

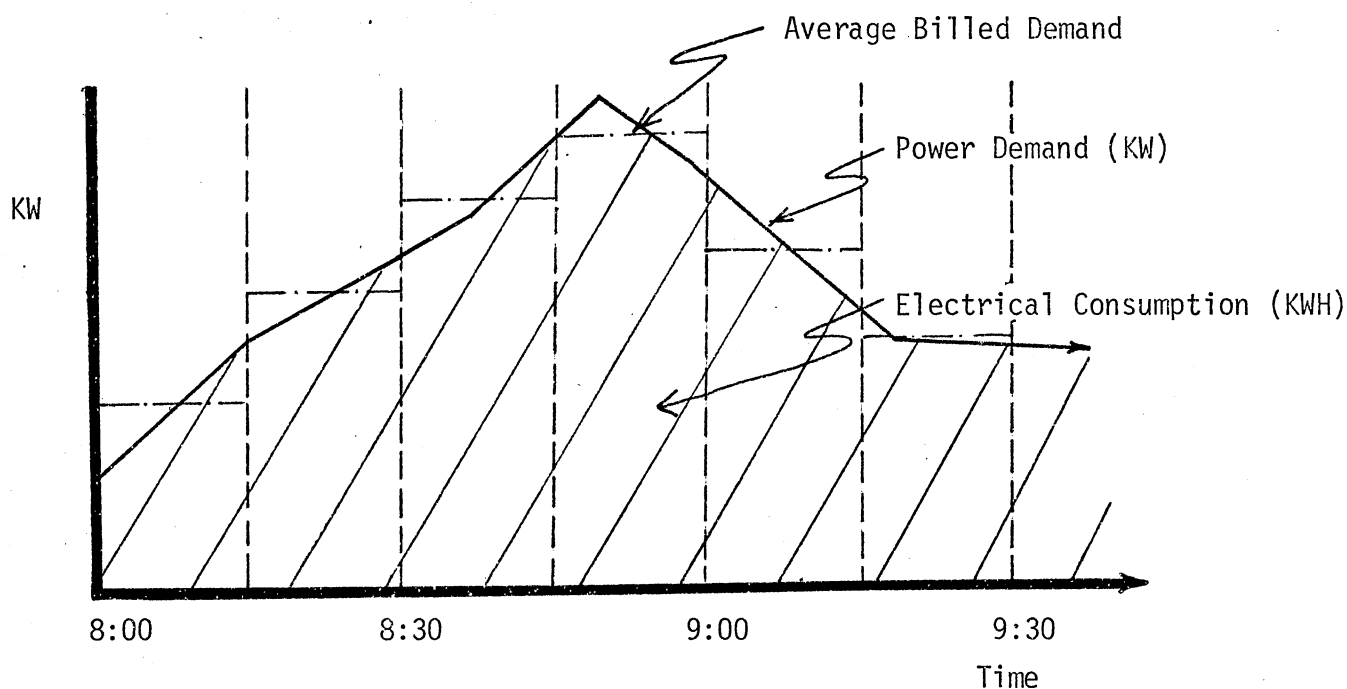
Demand Control

Many industries request utility billing structures containing demand charge penalties. The lower consumption charges help reduce utility bills of those companies who have controlled their power requirements. However, for companies not controlling their demand requirements, the penalties can be quite large. Demand penalty charges range from off-season costs of \$1.50 per kw to \$7.00 per kw greater than an established demand limit.

Proper scheduling, either manual or by computer, can lower electrical consumption profiles, shaving off costly demand peaks. Ventilation units, material handling systems; etc., through proper scheduling may be operated during off peak periods or controlled, by momentarily turning off as demand limits encountered, without adversely affecting facility operations. A detailed investigation into demand control can yield substantial savings.

Definition of Power Demand

The amount of electrical power required during a production period varies according to the type and number of processes operating during a period of time. Many facilities are charged for their consumption and penalized for the power demand placed upon the electrical utility company. Demand is defined as the electrical power requirements of an industrial facility, averaged over a specified period of time, usually 15 to 30 minutes. (Although in some areas of the country, the time period is as short as five minutes.) The demand is averaged over a period to allow instantaneous peaks, which do not affect the utility company. The highest average demand during a billing period is the basis for demand billing. Demand, measured in kw is related to consumption as shown in Figure V.



Consumption Profile
Figure V

Ratchet Clauses

In many areas, ratchet clauses are becoming increasingly popular with utility companies. A ratchet clause means the utility may charge a facility, based on the highest demand over a specified time period, e.g., six months. That is, if your plant's highest demand was four months ago, the facility is still charged on 65 percent of this value or the present demand, whichever is greater. (Percentages and time periods vary with electrical utility rate structures.)

Demand Clause Justification

A utility company must size its power generating equipment to generate enough power to always service its customer's demands. For example, if during the first thirty minutes of a working period, all processes are operating, this sudden demand surge must be satisfied by the power company. But, after this initial peak, the electrical consumption profile decreases and stabilizes at a much lower power level. Therefore, the utility company must penalize its industrial customers for demand peaks which tax the generating station.

Ratchet clauses, though economically harsh, help protect utility company's investments. For example, a plant may now have demand control, however, the utility had to initially design its system to supply a previously much higher power demand. Also, in the event the facility demand controller fails, the utility can supply any unusually large power demands.

Demand Scheduling

There are a number of effective methods used in reducing demand peaks. The first that should be considered is proper scheduling to

avoid simultaneous motor start ups or unnecessary process operations. As an example, operate large electrical consumers at night, when possible. A small municipal utility company had to operate a 800 horsepower pump eight hours per day. They rescheduled it to operate at night, avoiding a high demand peak during the day. The demand charge, \$1.40/kw-month, was small by present standards, however, the utility still saved over \$10,000 per year. Another cost effective practice is to avoid starting large electrical consumers simultaneously. A metal fabricating facility operated twelve 30 kw resistance furnaces for periods of two hours during the work period. (They consumed 10 kw when holding). The furnaces were rescheduled to allow no more than two to operate at the same time, to avoid large power demands. When all furnaces were allowed to operate at the same time the demand measured 360 kw or at \$1.50/kw-month, \$540 per month. By rescheduling, the demand dropped to 160 kw (2 furnaces x 30 kw + 10 furnaces x 10 kw) or a potential savings of 200 kw and \$3600 each year. Therefore, spread electrical power loads over the entire day, utilizing as much of the off-peak electrical periods as feasible. This scheduling concept may become increasingly important as utilities implement rate structures where the electrical cost varies with the time of day.

The market is crowded with devices for demand shedding, ranging from simple "hard wire" devices to microprocessors. The hard line device is relatively rigid, performing just the operation of demand control in the facility. The microprocessor, on the other hand, may serve a number of other functions in the facility as well as demand control. Inventory control, accounting, process control, etc. are just some of the ways to utilize a microprocessor. The selection

for your business is beyond the scope of this study because each application will vary according to process type, facility size, capital available, etc. This study will investigate a microprocessor which turns off non-essential electrical consumers as the demand limit is encountered. At this point, it is necessary to emphasize that motors turned off by the microprocessor must not affect plant operations. Many microprocessors "remember" which motors are bypassed and give them priority. Also, careful study, concerning individual motor duty cycles should be made before programming.

Computer Application

The computer program will simulate one, eight hour period with a virtually unlimited number of electric motors and peak demand limits in facilities with either demand controllers or without controlled power demands. For analysis purposes, do both. The program data necessary includes--motor horsepower, motor loads, demand limit, and energy costs. STOP - try it. If you have more questions, see the example in the next section. The computer requires a rigid format that must be followed.

Step 1: After the computer is in the *READY* mode
enter *EXEC ENERGY*.

Step 2: From this point, the computer will prompt the user as necessary with a ? when data is needed. Important!! When entering a decimal value, place a zero before the decimal point (e.g., *0.8* not just *.8*). Enter *2*, when appropriate, to run the demand controller.

Demand Control Example

A medium size job shop in central Oklahoma is billed with a demand penalty. The facility has a series of large horsepower motors which are being controlled using a microprocessor. As the electrical power demand approaches the programmed demand limit, predetermined motors are momentarily turned off without adversely affecting plant operations. The monthly demand charge is \$2.00 multiplied by the highest demand of the billing period. This example assumes the peak demand occurs during this simulated eight hour period.

Data

Motor	Horsepower	Load
1	50	0.70
2	50	0.80
3	75	0.70
4	100	0.70
5	100	0.50
Demand Limit		100 kw
Demand Cost		\$2.60/kw-billing period

The results of two simulations, one controlled demand and one with uncontrolled power demand are present in Table II. The operating time for each motor is approximately the same, averaging 228 minutes per working day for the uncontrolled demand simulation. Constrastingly, the operating times for controlled demand are drastically smaller, averaging 121 minutes per working day. The differences in monthly costs reflect this as the controlled simulation costs were \$150.13 as compared with the \$386.53 uncontrolled period cost--a savings of \$236.40

per month. With the programmed demand limit of 100 kw the actual highest average demand was 75.07 kw while during the uncontrolled period the demands fluctuated from 99.73 kw to as high as 193.27 kw.

Motor	Operating Time (minutes)	
	Controlled Simulation	Uncontrolled Simulation
1	119	227
2	154	232
3	160	230
4	85	237
5	87	217
Costs	\$ 150.13	\$ 386.53
Highest Average Demand	75.07 kw	193.27 kw

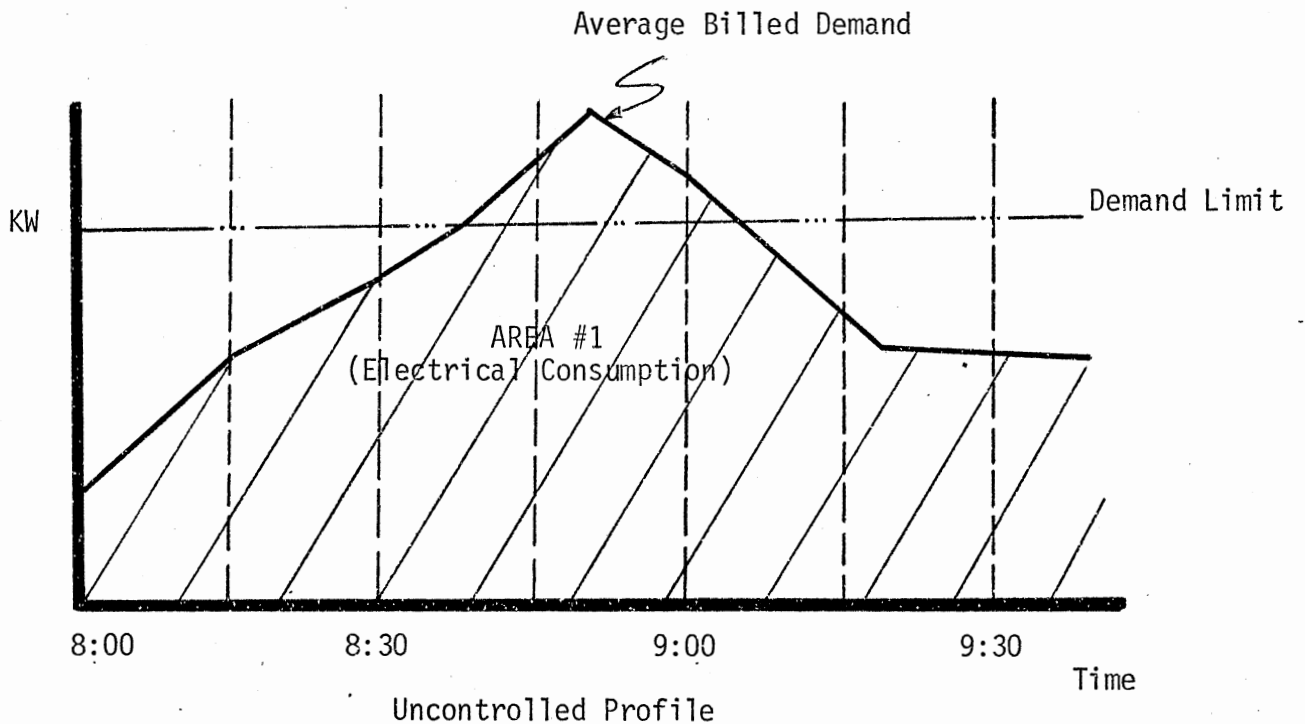
Demand Simulation Results

Table II

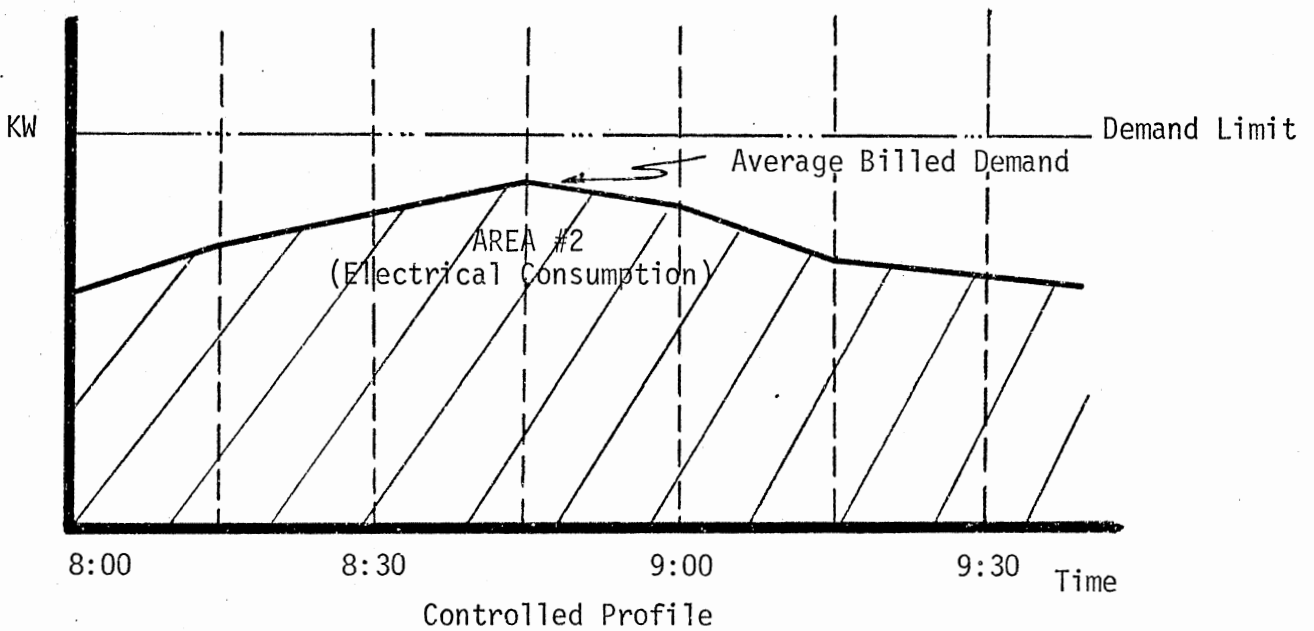
The simulation results are a little misleading but will help the reader understand the theory behind the demand controller. There is a substantial demand savings; however, the operating hours will not be as small. The microprocessor will keep track of the motor operations, allowing each to run as much as necessary. The demand peaks will disappear, as the consumption profile absorbs the difference. The average period consumption will not increase, however, the variance about that average will greatly decrease as illustrated in Figure VI.

Both power factor improvement and demand control have proven energy management potential. The paybacks associated with each are

well within most corporate requirements, thus, they should be considered by all industry. Many of the basic principles discussed in



AREA #1 = AREA #2



Demand Reduction Profile

Figure VI

the previous modules can be applied to reduce general consumption of electricity throughout the facility.

Electrical Consumption

Proper scheduling of electrical processes and supervision of equipment operating hours are two effective ways of reducing electricity costs. Scheduling can have two fold benefits, a reduction in electrical consumption costs due to more prudent operation and reduction of power demands throughout the day. Many areas of the U.S. are considering time of day pricing structures, where the cost of electricity is generally higher during the day and allows cost savings for night time usage. If affected by such structures, the facility should consider scheduling schemes that operate feasible equipment during off-peak periods to avoid potentially high consumption costs.

In a typical facility, many electrical processes continue to operate during breaks, between shifts, etc. Proper supervision and timers can reduce the operating time, for example, a facility might place limit switches, photoelectric eyes, etc., at the beginning of a stretch of conveyor. If the switch does not detect anything on the conveyor, for a specified period of time, the conveyor will stop until products arrive and must be transported. Controlled lighting, another good example, demonstrates substantial energy management potential for turning off lights when not in use. One professional journal suggests fluorescent lights should be turned off when not in use for more than fifteen minutes. Therefore, simple energy awareness, and employee participation can result in energy savings.

Another rewarding area where energy saving ideas are relatively easy to implement and have proven savings is in heating, ventilating,

and air conditioning. Energy management ideas in this area have substantial potential, as much of a manufacturer's utility bill is involved in HVAC systems as will be seen.

HEATING, VENTILATING, AND AIR CONDITIONING CONTROL

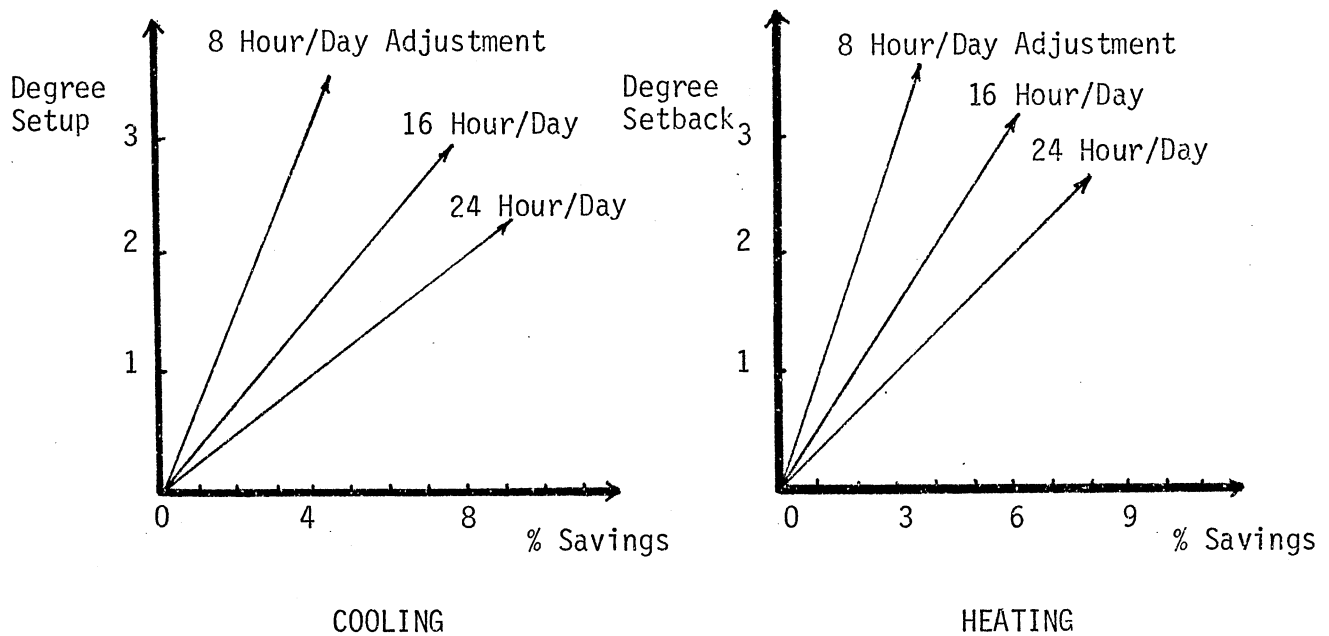
Temperature Control

Energy cost reductions using temperature control have great potentials, but must be implemented carefully to insure present productivity levels continue. Gradual implementation of thermostat set ups and set backs will allow employees to readjust to their changing environment. Also, if they are aware of the company energy management goals and their corresponding energy and monetary savings, they will exhibit more enthusiasm with company efforts.

Environmental Standards

Concentrated effort in thermostat adjustment will accomplish dual objectives, saving a substantial amount of the present energy costs and demonstrating to company employees that management is committed to energy management. As shown in Figure VI, significant savings in cooling and heating bills, can be realized by simply adjusting present thermostat settings. These values are difficult to justify, but in various applications they appear to be very close. In a similar study by the U.S. Air Force, the potential savings are higher.

In many industrial facilities the heating, ventilating and air conditioning costs represent a major portion of their energy bills. As examples, General Motors Company's HVAC systems consume 31.7 percent of its total energy supply, (8), and one Oklahoma industry consumes greater than 60% in its HVAC systems. Savings in this area are relatively simple and very cost effective by simply meeting recommended standards, Table III. In another example, a medium size industrial facility, 105,000 square feet, turned off the air conditioning at



Relationship of Temperature to Operating Costs

Figure VI

night and saved over \$16,000 per year. (43) Automatic controls, timers, 24 hour thermostats, seven day thermostats and microprocessors can regulate and adjust temperature settings relieving supervisory requirements.

Cooling Potential

Air conditioning costs can be greatly reduced by raising thermostat settings, as this study will use a four percent savings per degree set up from a 72° F per 24 hours. For example, if a facility turns its thermostat up from 72° F to 78° F for a ten hour period

	Heating		Cooling
	Dry Bulb °F Occupied hrs.	Dry Bulb °F Unoccupied hrs.	Dry Bulb °F Occupied hrs.
Offices and general purpose administrative	68	55	78
Infirmaries, patient areas	72-76	72-76	75-78
General purpose academic space	68	60	78
General recreation areas	60	55	Do not cool
Research, laboratories, surgical suites, and other critical space	As reqd.	As reqd.	As reqd.
Conference rooms, auditoriums	68	50	78
Multi-family—living areas	68	60	78
General purpose stores, sales areas	65	55	78
Cafeterias, dining halls	68	50	78
Industrial, production areas	60-68	55	72-78
Warehouses	55	50	Do not cool
Docks and Platforms	Do not heat	Do not heat	Do not cool
Toilet rooms	65	50	78
Corridors & Lobbies	68	55	80
Storage & Equipment rooms	55	50	Do not cool

Recommended Thermostat Settings

Table III

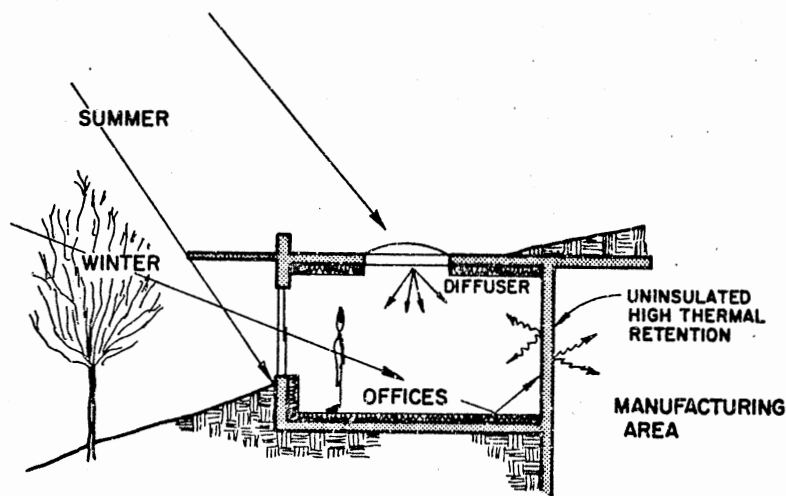
(overnight), it will save approximately

$(78-72^{\circ}\text{F}) \times 10/24 \text{ hours} \times 4\% \text{ savings} = 10\% \text{ of its cooling bill.}$

If these adjustments are made for longer periods of time and/or with greater temperature differences, the savings will increase proportionally.

In addition to temperature control, there are a number of methods which will increase energy savings. Consider adding economizer cycles to existing air conditioning systems which draw in outside air, when appropriate, to directly cool manufacturing areas. Reduce solar loads on southern and western walls by landscaping properly with trees, berms, foliage, etc., by installing correctly designed awnings, overhangs and partitions, Figure VII, and by using drapes, blinds and shades in office areas. Turn off unnecessary heat producers, coffee pots, hot

plates, lights, etc., which increase the cooling load of the facility. Most importantly, make sure outside windows and doors are properly weatherstripped and caulked, sealing in expensive conditioned air.



Solar Angle and Overhangs

Figure VII

Heating Potential

Heating energy savings are very similar to cooling savings and will be calculated as a three percent savings per degree set back from 72⁰ F per 24 hours. As stated previously, if temperature adjustments are implemented over longer periods, for example, on weekends, the total savings will be much greater.

Related to temperature control is infrared heating. Many areas on the manufacturing floor, dock areas, storage areas, etc., have the potential for use of infrared heaters for task heating. Infrared heaters use less energy than gas fuel heaters and they transfer their heat directly to the necessary area without wasting energy heating

the surrounding environment. Savings of 50% have been advertised when compared with direct fired gas heater applications.

Regional Control

Areas with significant temperature differences should be separated utilizing one of many techniques available for reducing infiltration, including plastic strip doors, dock door cushions, impact doors, etc. Plastic strip doors, a recent energy saving technique, are overlapping plastic strips hanging over an opening, that have various applications throughout the plant, ranging from dock areas to isolation of large ventilated areas. They allow unobstructed travel of both men and equipment, thus, may be applied in all areas of the facility.

In new facilities, areas with similar heating requirements, storage, dock areas, paint rooms, etc. should be placed near one another. Isolated in this way, HVAC equipment can be better designed and operate more efficiently. Areas requiring no heat should be grouped together on northern walls where they can serve as insulation barriers between the manufacturing areas and the outside environment.

Computer Application

This subroutine will calculate potential savings in heating and cooling control using data furnished by the user, including energy required by HVAC systems, temperature adjustments and hours of adjustment. Several assumptions were necessary to simulate the example problem. STOP - try it. If you still have questions, consult the example problem description in the next section.

Assumptions:

- (1) The operating hours during the heating season are 15 hours per day, 30 days per month and four months per year. For cooling, the system is assumed to operate ten hours per day, 30 days per month for four months per year.
- (2) The energy costs were determined using 1979 Oklahoma utility estimates.

To use the computer program, follow the rigid procedures presented below.

Step 1: After the computer is in the *READY* mode, enter
EXEC ENERGY.

Step 2: From this point, the computer will prompt the user with a ? when data is necessary. Important!! When entering a decimal value, place a zero before the decimal point (e.g., 0.8 not just .8). Enter 3 when appropriate to run temperature control.

Temperature Control Example

Substantial energy savings can be realized by simply adjusting thermostat settings to recommended standards and even greater savings for further adjustment at night and on weekends. This routine example assumes an overnight, ten hour adjustment. Approximately three percent savings per degree setback and four percent savings per degree set up, from a base of 72⁰ F, can be realized from heating and cooling bills.

Data

Thermostat Settings

Base	72°F
Setback	68°F
Setup	78°F

HVAC Energy Input

Heat	60,000 BTU/hr
Cool	30,000 BTU/hr

Operating hours

Heat	1800 hr/season
Cool	1200 hr/season

Adjustment Period	10 hr/day
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Energy Costs

Heat	$\$1.6 \times 10^{-6}/\text{BTU}$
Cool	$\$4 \times 10^{-6}/\text{BTU}$

Cooling Setup Potential

$$\begin{aligned}
 \text{COOLING COST} &= \text{ENERGY INPUT} \times \text{HOURS OF OPERATION} \times \text{COOLING COST} \\
 &= 30,000 \text{ BTU/hr} \times 1200 \text{ hr/season} \times \$4 \times 10^{-6}/\text{BTU} \\
 &= \$144.00
 \end{aligned}$$

$$\begin{aligned}
 \text{SAVINGS} &= (4\% \times (78-72^\circ\text{F}) \times 10/24 \text{ hr}) \times \$144.00 \\
 &= \$14.40
 \end{aligned}$$

Heating Setback Potential

$$\begin{aligned}\text{HEATING COST} &= 60,000 \text{ BTU/hr} \times 1800 \text{ hr/season} \times \$1.6 \times 10^{-6}/\text{BTU} \\ &= \$172.80\end{aligned}$$

$$\begin{aligned}\text{SAVINGS} &= (3\% \times (72-68^{\circ}\text{F}) \times 10/24 \text{ hr}) \times \$172.80 \\ &= \$8.64\end{aligned}$$

Again, these savings represent just a night time change for a very small HVAC unit. If these were implemented for the entire day and further controlled on weekends, the savings would be substantially greater.

Another aspect of HVAC control is the distribution of conditioned air throughout the facility. Many industrial facilities are overly ventilated, wasting energy in conditioning and air distribution.

Ventilation Control

Heating and cooling units will be different from one facility to the next; however, the majority of industrial HVAC units will have similar air handling distribution systems. Air handling units are a series of small horsepower fans that draw fresh, outside make up air through conditioning units and distribute the air throughout the plant via a system of ventilation ducts.

Industrial Ventilation

Ventilation equipment operation requires a great amount of electrical energy, and correspondingly, substantial costs. For example, a medium size, three story, office building in northern Oklahoma spends on an average of \$12,000 per year just to operate fan units. A number of energy management techniques are available to reduce fan operating requirements, ranging from task ventilation and system modification to electrostatic precipitators.

Heating and air conditioning units require fresh make up air, which must be heated or cooled and filtered to meet facility temperature and conditioning requirements, to replace existing conditioned air in manufacturing areas. Small multiple fan units push conditioned air through a system of distribution ducts to specific outlet locations. Thus, reducing the amount of conditioned make up air will yield a dual savings; energy required to heat or cool the make up air will be reduced and the energy required to operate fan motors can be substantially reduced. The savings can be very large.

Ventilation Reduction

The Occupational Safety and Health Administration, OSHA, has established standards for required make up air volumes for various manufacturing areas. These standards should be followed as closely as possible; however, many facility HVAC systems are over designed with larger horsepower motors and air capacities than necessary. As an example, a manufacturing area contains a small welding operation, where the make up air changes are much greater than the remainder of the manufacturing area. However, in this facility, as in many others, the entire fabricating area is conditioned by a central unit; thus, the make up air capacity is designed to satisfy the welding area requirements. A proven solution to this type problem is to isolate the welding area and task ventilate using specially designed ventilation hoods for the welding area and reduce the make up air requirements of the remainder of the facility.

Electrostatic precipitators, excellent for use in "dirty air" areas, such as, welding areas, grinding areas, etc., are gaining acceptance

across the country. They are available in a variety of sizes and models ranging from small, office models to large volume types. Their major advantage is the air, after being cleaned, can be recirculated without further energy usage in heating or cooling.

Two more cost effective energy management techniques are polyethylene air distribution tubes and "barber shop" air circulating fans. Their objective is to push hot conditioned air, near high facility ceilings down to manufacturing floors where needed, thus decreasing the heating load of the facility HVAC system. The tubes draw in cool outside air, and through small holes in the tube, mix this make up air with the hot ceiling air, which then falls by convection to the facility floor. Similarly, fans, high in the facility, force ceiling air down where it can be used and, consequently, substantially reduces heating bills.

Potential Ventilation Savings

This study is concerned with the savings available with reductions in make up air requirements and will not investigate electronic precipitators or ventilation hoods, as each must be tailored for particular applications. As mentioned previously, the potential savings are twofold, first, resulting from reduction in heating and cooling energy requirements as shown in the following expression.

$$\begin{aligned} \$ \text{ SAVINGS} = & \frac{.24 \text{ BTU}}{16^{\circ} \text{ F}} \times \frac{.0751 \text{ b}}{\text{ft}^3} \times \frac{\text{ft}^3}{\text{min}} \times \Delta T^{\circ} \text{ F} \times \frac{t}{\text{yr}} \times \\ & \frac{\$ \text{ COST}}{\text{BTU}} \times \frac{60 \text{ min}}{\text{hour}} \end{aligned}$$

where

$$\frac{.24 \text{ BTU}}{16^{\circ}\text{F}} = \text{specific heat of air}$$

$$\frac{.0751\text{b}}{\text{ft}^3} = \text{specific gravity of air}$$

Another substantial saving, shown below, is available in fan horsepower reduction. Since the make up air requirements have been reduced, the total volume of air to be moved has been correspondingly decreased.

$$\text{HP SAVE} = \text{PRESENT FAN HORSEPOWER} - \left[\left(1 - \frac{\text{DMAKE}}{\text{PMAKE}} \right)^3 \times \text{PRESENT FAN HORSEPOWER} \right]$$

where

DMAKE = desired make up air requirements

PMAKE = present make up air requirements

Computer Application

The ventilation control subroutine will calculate the potential savings in both heating and cooling energy requirement reduction and in decreasing necessary fan motor ratings. The program is very flexible, data to be entered ranges from present and desired make up air requirements to the estimated seasonal operating hours. To simulate, follow the rigid procedures discussed below. An example is simulated on the computer. STOP - try it; then if you have any questions, see the example in the next section.

Step 1: After the computer is in the *READY* mode enter

EXEC ENERGY.

Step 2: From this point, the computer will prompt the user with a ? when data is necessary. Important!! When entering a decimal value, place a zero before the decimal point. (e.g., 0.8 not just .8) Enter 4 when appropriate to run Ventilation Control.

Ventilation Control Example

A small size manufacturing facility in Stillwater, Oklahoma, is located in a well insulated metal prefabricated building. Heating and cooling is supplied by a central unit operating with a ten horsepower air handler. After analysis of present air changes and OSHA required air changes, the company has determined it may reduce present ventilation requirements, and correspondingly, reduce the fan motor horsepower.

Data

Present Make Up Air Requirements	12500 CFM
Desired Make Up Air Requirements	6250 CFM
Indoor Thermostat Setting	72 ⁰ F
Winter Design Temperature	40 ⁰ F
Summer Design Temperature	80 ⁰ F
Winter Operating Hours	1800
Summer Operating Hours	1200
Fan Horsepower	10
Energy Cost	\$4 X 10 ⁻⁶ /BTU

Calculate the present cost and potential heating and cooling savings.

$$\text{HEAT COST} = .24 \frac{\text{BTU}}{16^{\circ}\text{F}} \times \frac{.075 \text{ lb}}{\text{ft}^3} \times 12500 \frac{\text{ft}^3}{\text{min}} \times \frac{60 \text{ min}}{\text{hour}} \times (72 - 40^{\circ}\text{F}) \times \frac{1800 \text{ hr}}{\text{season}} \times \$4 \times 10^{-6} / \text{BTU} = \$3110.40 / \text{season in heating costs.}$$

$$\begin{aligned}
 \text{COOL COST} &= \frac{.24 \text{ BTU}}{16^{\circ}\text{F}} \times \frac{.0751 \text{ b}}{\text{ft}^3} \times \frac{12500 \text{ ft}^3}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}} \times (80-72^{\circ}\text{F}) \times \\
 &\quad \frac{1200 \text{ hr}}{\text{yr}} \times \frac{\$4 \times 10^{-6}}{\text{BTU}} \\
 &= \$518.40/\text{year cooling costs}
 \end{aligned}$$

The potential savings for heating and cooling energy reduction due to decreased air volume are \$1555.20 and \$259.20, respectively.

$$\begin{aligned}
 \text{HEAT SAVE} &= \frac{.24 \text{ BTU}}{16^{\circ}\text{F}} \times \frac{.0751 \text{ b}}{\text{ft}^3} \times \frac{(12500-6250 \text{ ft}^3)}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}} \times \\
 &\quad (72-40^{\circ}\text{F}) \times \frac{1800 \text{ hr}}{\text{yr}} \times \frac{\$4 \times 10^{-6}}{\text{BTU}} \\
 &= \$1555.20/\text{year in heating cost savings}
 \end{aligned}$$

$$\begin{aligned}
 \text{COOL SAVE} &= \frac{.24 \text{ BTU}}{16^{\circ}\text{F}} \times \frac{.0751 \text{ b}}{\text{ft}^3} \times \frac{(12500-6250 \text{ ft}^3)}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}} \times \\
 &\quad (80-72^{\circ}\text{F}) \times \frac{1200 \text{ hr}}{\text{yr}} \times \frac{\$4 \times 10^{-6}}{\text{BTU}} \\
 &= \$259.20/\text{year in cooling cost savings}
 \end{aligned}$$

The cost of operating the fan is now calculated

$$\begin{aligned}
 \text{FAN COST} &= 10 \text{ hp} \times \frac{.746 \text{ kw}}{\text{hp}} \times \frac{10000 \text{ BTU}}{\text{kw}} \times \frac{3000 \text{ hr}}{\text{yr}} \times \frac{\$4 \times 10^{-6}}{\text{BTU}} \\
 &= \$895.20/\text{year in fan operations}
 \end{aligned}$$

The potential cost reduction and decrease in fan horsepower are \$783.30 per year and 8.75 hp, respectively.

$$\text{FAN SAVE} = \$895.20 \left(1 - \frac{6250}{12500}\right)^3 \times 10 \text{ hp} \times \frac{.746 \text{ kw}}{\text{hp}} \times 10000 \frac{\text{BTU}}{\text{kw}} \times$$

$$3000 \frac{\text{hp}}{\text{yr}} \times \frac{\$4 \times 10^{-6}}{\text{BTU}}$$

$$= \$783.30/\text{year in fan operations}$$

$$\text{HP SAVE} = 10 \text{ hp} - \left[\left(1 - \frac{6250}{12500}\right)^3 \times 10 \text{ hp} \right]$$

$$= 8.75 \text{ hp reduction in required horsepower}$$

Therefore, for this small system, the total potential savings, by lowering ventilation levels to OSHA standards are \$2598.00 each year. In manufacturing facilities, with multiple HVAC units, the analysis should include the total HVAC system and will correspond closely with the previous calculations.

SUMMARY

Industry, concerned with rising energy costs, is concentrating effort to reduce present energy bills; however, many managers do not have the background to select cost effective energy management opportunities. This study sensitizes people with the current energy situation and introduces four proven cost effective energy saving ideas, power factor improvement, demand control, temperature control, and ventilation control, implemented in various situations across the country.

The study, energy manual and interactive computer program, is anticipated to aid industry, across the state of Oklahoma, in selecting proven energy saving alternatives. Students, enrolled in industrial energy management courses, will receive, through use of this manual, the necessary background to assume a responsible position in a profit improving industrial energy management program.

The modular design of this study promotes additional research. Modules can be easily added to the energy manual and the interactive computer program can be expanded by integrating additional subroutines with the existing software. Suggested ideas for future study include optimum insulation sizing, lighting replacement, reduction in hot water temperatures, reduction of compressed air pressures and waste heat recovery applications.

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APPENDIX A

Example Print Out

ENERGY SIMULATOR

THIS PROGRAM ALLOWS MANAGERS TO TEST THE COST EFFECTIVENESS OF THEIR ENERGY SAVING IDEAS. THE COMPUTER WILL PROMPT THE USER AS NECESSARY.

IF YOU WISH TO SELECT AN ENERGY SAVING IDEA ENTER "1" ; HOWEVER IF YOU WISH STOP THE SIMULATION ENTER "0".

?

1

YOU DO WANT TO SELECT AN ENERGY SAVING IDEA - CORRECT? ENTER "1" - YES "0" -

?

1

THE FOLLOWING IS A LIST OF ENERGY SAVING IDEAS PRESENTED ON THIS PROGRAM
ENTER THE NUMBER BESIDE THE APPROPRIATE ENERGY IDEA.

1--POWER FACTOR ANALYSIS
2--DEMAND CONTROLLER
3--TEMPERATURE CONTROL
4--VENTILATION CONTROL

?

1

POWER FACTOR ANALYSIS

A MEDIUM SIZED METAL FABRICATING PLANT IN PERRY, OKLAHOMA UTILIZES A LARGE NUMBER OF OVERLY SIZED INDUCTION MOTORS AND WELDERS. LIGHTING IS FURNISHED BY SEVERAL HUNDRED EIGHT FOOT FLUORESCENT LIGHTS. AT THE PRESENT TIME, THE FACILITY IS PAYING A PENALTY FOR BAD POWER FACTOR AND IS CONSIDERING CAPAC

DO YOU WISH TO RUN POWER FACTOR? ENTER "1" - YES "0" - NO

57

?

1

DO YOU WISH TO SEE AN EXAMPLE? ENTER "1" - YES "0" - NO.

?

1

THE PENALTY CHARGE IS CALCULATED USING A PERCENTAGE OF THE DEMAND CHARGE.
POWER FACTORS GREATER THAN 0.8 WILL OFTEN YIELD A BONUS. THE CAPACITOR
COST IS APPROXIMATELY \$18.50 PER KVAR.

PRESENT POWER FACTOR - 0.50
MONTHLY PENALTY COST-\$ 640.00
DESIRED POWER FACTOR - 0.80
CAPACITOR COST-\$3459.50
PAYBACK - 14.41 MONTHS
IF YOU HAVE ANY QUESTIONS SEE MANUAL PAGE

DO YOU WISH TO RUN POWER FACTOR? ENTER "1" - YES "0" - NO

?

0

IF YOU WISH TO SELECT AN ENERGY SAVING IDEA ENTER "1" ; HOWEVER IF YOU WISH
STOP THE SIMULATION ENTER "0".

?

1

YOU DO WANT TO SELECT AN ENERGY SAVING IDEA - CORRECT? ENTER "1" - YES "0" - NO

?

1

THE FOLLOWING IS A LIST OF ENERGY SAVING IDEAS PRESENTED ON THIS PROGRAM
ENTER THE NUMBER BESIDE THE APPROPRIATE ENERGY IDEA.

1--POWER FACTOR ANALYSIS
2--DEMAND CONTROLLER
3--TEMPERATURE CONTROL
4--VENTILATION CONTROL

?

2

A MEDIUM SIZED JOB SHOP IN CENTRAL OKLAHOMA IS BILLED WITH A DEMAND PENALTY. THE FACILITY HAS A SERIES OF LARGE HORSEPOWER MOTORS WHICH ARE BEING CONTROLLED USING A SMALL MICROPROCESSOR. AS THE DEMAND APPROACHES THE LIMIT, THE MOTORS ARE MOMENTARILY SHUT OFF. DEMAND CHARGE IS \$2.00 MULTIPLIED BY THE HIGHEST AVERAGE DEMAND.

DO YOU WISH TO RUN DEMAND CONTROLLER? ENTER '1' - YES '0' - NO

?

1

DO YOU WISH AN EXAMPLE? ENTER '1' -YES '0' -NO

?

1

DO YOU WANT DEMAND CONTROL? ENTER '1' - YES '0' - NO.

?

0

THIS PROGRAM SIMULATES WORK PERIOD WITH NO DEMAND CONTROL.

THE MOTOR HORSEPOWERS ARE

50	50	75	100	100
OPERATING TIME FOR MOTOR				
1	227			
OPERATING TIME FOR MOTOR				
2	232			
OPERATING TIME FOR MOTOR				
3	230			
OPERATING TIME FOR MOTOR				
4	237			
OPERATING TIME FOR MOTOR				
5	217			
TOTAL KILOWATT HOURS FOR MOTOR				
1	111			
TOTAL KILOWATT HOURS FOR MOTOR				
2	111			
TOTAL KILOWATT HOURS FOR MOTOR				
3	165			
TOTAL KILOWATT HOURS FOR MOTOR				
4	222			
TOTAL KILOWATT HOURS FOR MOTOR				
5	222			
THE AVERAGE DEMAND EACH FIFTEEN MINUTES IS --				
110.80	141.60	134.13	124.27	99.73
141.53	116.93	156.33		
114.53	134.27	121.87	134.27	105.93
123.00	140.40	130.53		
134.13	146.47	135.40	136.67	146.60
135.40	141.60	110.87		
145.27	126.80	101.00	193.27	155.07
137.87	119.40	119.33		
THE MAXIMUM AVERAGE DEMAND IS 193.27				
THE TOTAL DEMAND CHARGE FOR THE MONTH IS 386.53				
IF YOU HAVE ANY QUESTIONS, SEE MANUAL PAGE				

DO YOU WISH TO RUN DEMAND CONTROLLER? ENTER '1' - YES '0' - NO

?
1
DO YOU WISH AN EXAMPLE? ENTER "1" -YES "0" -NO

59

?
1
DO YOU WANT DEMAND CONTROL? ENTER "1" - YES "0" - NO.

?
1

THE MOTOR HORSEPOWERS ARE

50	50	75	100	100
OPERATING TIME FOR MOTOR	1	119		
OPERATING TIME FOR MOTOR	2	154		
OPERATING TIME FOR MOTOR	3	160		
OPERATING TIME FOR MOTOR	4	85		
OPERATING TIME FOR MOTOR	5	87		

TOTAL KILOWATT HOURS FOR MOTOR	1	37
TOTAL KILOWATT HOURS FOR MOTOR	2	74
TOTAL KILOWATT HOURS FOR MOTOR	3	110
TOTAL KILOWATT HOURS FOR MOTOR	4	74
TOTAL KILOWATT HOURS FOR MOTOR	5	74

THE AVERAGE DEMAND EACH FIFTEEN MINUTES IS --

56.60	68.87	63.93	64.00	57.87	52.87	56.53	67.67
70.20	66.47	61.47	67.67	75.07	73.80	73.73	66.47
70.13	70.00	70.00	67.67	56.60	59.00	62.73	67.73
71.47	68.87	67.73	67.67	72.67	56.60	73.80	62.73

THE MAXIMUM AVERAGE DEMAND IS 75.07

THE TOTAL DEMAND CHARGE FOR THE MONTH IS 150.13

IF YOU HAVE ANY QUESTIONS, SEE MANUAL PAGE

DO YOU WISH TO RUN DEMAND CONTROLLER? ENTER "1" - YES "0" - NO

?
0
IF YOU WISH TO SELECT AN ENERGY SAVING IDEA ENTER "1" ; HOWEVER IF YOU WISH
STOP THE SIMULATION ENTER "0".

?
1
YOU DO WANT TO SELECT AN ENERGY SAVING IDEA - CORRECT? ENTER "1" - YES "0" - NO

?
1
THE FOLLOWING IS A LIST OF ENERGY SAVING IDEAS PRESENTED ON THIS PROGRAM
ENTER THE NUMBER BESIDE THE APPROPRIATE ENERGY IDEA.

1--POWER FACTOR ANALYSIS

 TEMPERATURE CONTROL

SUBSTANTIAL SAVINGS CAN BE REALIZED BY SIMPLY ADJUSTING THERMOSTAT SETTINGS.
 APPROXIMATELY 3% PER DEGREE SETBACK AND 4% PER DEGREE SETUP FROM A
 BASE 72 F FROM THE HEATING AND COOLING BILLS.

DO YOU WISH TO RUN TEMPERATURE CONTROL? ENTER '1' - YES '0' - NO

?
 1
 DO YOU WISH TO SEE AN EXAMPLE? ENTER '1' - YES '0' - NO

?
 0
 DO YOU WISH TO ENTER YOUR DATA? ENTER '1' - YES '0' - NO

?
 1
 ENTER DATA AS REQUESTED BY THE COMPUTER IF NECESSARY TO CHANGE.
 IMPORTANT!!
 WHEN ENTERING DECIMAL VALUES, PLACE ZERO BEFORE THE DECIMAL POINT

THE PRESENT THERMOSTAT SETTING IS 72.00 F
 DO YOU WISH TO CHANGE? ENTER '1' - YES '0' - NO

?
 0
 THE SETBACK THERMOSTAT SETTING IS 68.00 F
 THE SET UP THERMOSTAT SETTING IS 78.00 F
 DO YOU WISH TO CHANGE? ENTER '1' - YES '0' - NO

?
 0
 THE HOURS SETBACK ARE 10.00
 THE HOURS OF SET UP ARE 10.00
 DO YOU WISH TO CHANGE? ENTER '1' - YES '0' - NO

?
 0
 APPROXIMATELY ONE TON OF CONDITIONING=1 KWH =10000 BTU

THE HEATING ENERGY INPUT IS 60000.00 BTU
 THE COOLING ENERGY INPUT IS 30000.00 BTU

?
0
THE ESTIMATED SEASONAL HEATER OPERATING HOURS IS 1800.00 61
THE ESTIMATED SEASONAL AIR CONDITIONING OPERATING HOURS IS 1200.00
DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO

?
0
THE BTU COST OF GAS IS APPROXIMATELY \$1.60/KCF * KCF/1000000 BTU = 0.0000016
THE BTU COST OF ELECTRICITY IS APPROXIMATELY \$0.04/KWH * KWH/10000 BTU = 0.000004
DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO

?
0
THE ESTIMATED NORMAL THERMOSTAT SETTING IS 72.00 F
HEATING ENERGY INPUT IS 60000.00 BTU
THE COOLING ENERGY INPUT IS 30000.00 BTU
THE OPERATING HOURS DURING THE HEATING SEASON ARE 1800.0000
THE OPERATING HOURS DURING THE COOLING SEASON ARE 1200.0000
THE DESIRED SETBACK TEMPERATURE IS 68.00 F
THE DESIRED SET UP TEMPERATURE IS 78.00 F
THE SETBACK TIME IS 10.00 HOURS PER DAY
THE SET UP TIME IS 10.00 HOURS PER DAY
THE HEATING COST IS \$ 0.00000160 PER BTU
THE COOLING COST IS 0.00000400 PER BTU

THE HEATING COSTS PER YEAR ARE \$ 172.80
THE POTENTIAL HEATING SAVINGS ARE \$ 8.64

THE COOLING COSTS PER YEAR ARE \$ 144.00
THE POTENTIAL SAVINGS ARE \$ 14.40

IF YOU HAVE ANY QUESTIONS SEE MANUAL PAGE .

DO YOU WISH TO RUN TEMPERATURE CONTROL? ENTER "1" - YES "0" - NO

?
0
IF YOU WISH TO SELECT AN ENERGY SAVING IDEA ENTER "1" ; HOWEVER IF YOU WISH TO
STOP THE SIMULATION ENTER "0".

?
1
YOU DO WANT TO SELECT AN ENERGY SAVING IDEA - CORRECT? ENTER "1" - YES "0" -

?
1
THE FOLLOWING IS A LIST OF ENERGY SAVING IDEAS PRESENTED ON THIS PROGRAM
ENTER THE NUMBER BESIDE THE APPROPRIATE ENERGY IDEA.

?
4

VENTILATION CONTROL

A LARGE SIZE MANUFACTURING FACILITY IN STILLWATER, OKLAHOMA IS LOCATED IN A WELL INSULATED METAL PREFABRICATED BUILDING. AFTER ANALYSIS OF PRESENT AIR CHANGES AND REQUIRED MAKE UP AIR CHANGES, THE COMPANY HAS DETERMINED IT MAY REDUCED PRESENT VENTILATION REQUIREMENTS

DO YOU WISH TO RUN VENTILATION CONTROL? ENTER '1' - YES '0' - NO

?
1
DO YOU WISH TO SEE AN EXAMPLE? ENTER '1' - YES '0' - NO

?
1
THE PRESENT MAKE UP AIR VOLUME IS 12500.00 CFM
THE DESIRED MAKE UP AIR VOLUME IS 6250.00 CFM
THE AVERAGE OUTDOOR HEATING SEASON TEMPERATURE IS 40.00 F
THE AVERAGE INDOOR HEATING SEASON TEMPERATURE IS 72.00 F
THE AVERAGE OUTDOOR COOLING SEASON TEMPERATURE IS 80.00 F
THE AVERAGE INDOOR COOLING SEASON TEMPERATURE IS 72.00 F
THE APPROXIMATE FAN OPERATING HOURS PER HEATING SEASON IS 1800.00 HOURS
THE APPROXIMATE FAN OPERATING HOURS PER COOLING SEASON IS 1200.00 HOURS
THE APPROXIMATE PRESENT FAN HORSEPOWER IS 10.00 HP
THE APPROXIMATE COST OF ELECTRICITY IS 0.00000400 PER BTU

THE HEATING SEASON VENTILATION COST IS \$3110.40
THE POTENTIAL SAVINGS ARE \$1555.20

THE COOLING SEASON VENTILATION COST IS \$ 518.40
THE POTENTIAL SAVINGS ARE \$ 259.20

THE FAN OPERATING COST IS \$ 895.20 PER YEAR
THE POTENTIAL SAVINGS ARE \$ 783.30
THE REDUCTION OF HORSEPOWER POSSIBLE IS 8.75
IF YOU HAVE ANY QUESTIONS SEE MANUAL PAGE

DO YOU WISH TO RUN VENTILATION CONTROL? ENTER '1' - YES '0' - NO

APPENDIX B
Sample Rate Structures

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA

64
DIVISION

STANDARD RATE SCHEDULE

C-1

CODE NO 06

Commercial Rate

COM

EFFECTIVE IN: All territory served.

AVAILABILITY: Alternating current for use other than a residential dwelling unit. Service will be rendered at one location at one voltage. For service at transmission voltage, see appropriate Power and Light Rate schedule.

No resale, breakdown, auxiliary or supplementary service permitted. Where commercial and residential service are served through one meter, the Commercial Rate is to apply to the entire load.

RATE:

On-Peak Season - (Bills for energy used during meter reading periods ending June 1 through October 31 of any year.)

First	50 kWh or less per month for \$3.99
Next	50 kWh per month @ 5.509¢ per kWh
Next	500 kWh per month @ 4.643¢ per kWh
Next	1400 kWh per month @ 4.019¢ per kWh
Next	3000 kWh per month @ 3.778¢ per kWh
All Additional	kWh per month @ 3.441¢ per kWh

Off-Peak Season - (Bills for energy used during meter reading periods ending November 1 of any year through May 31 of the succeeding year.)

First	50 kWh or less per month for \$3.99
Next	50 kWh per month @ 5.509¢ per kWh
Next	500 kWh per month @ 4.144¢ per kWh
Next	1400 kWh per month @ 3.134¢ per kWh
Next	3000 kWh per month @ 2.894¢ per kWh
All Additional	kWh per month @ 2.750¢ per kWh

LATE PAYMENT CHARGE: A late payment charge in an amount equal to one and one-half per cent (1 1/2%) of the total amount due on each monthly bill as calculated under the above rate will be added if the bill is not paid on or before the due date stated on the bill. The due date shall be ten (10) days after the bill is mailed.

MINIMUM BILL: \$3.99 per month (plus any applicable fuel cost adjustment) per meter for lighting and the use of socket appliances of less than 1 kilowatt and of motors with individual capacities of not more than one-half horsepower (or where there is no lighting, the first horsepower of connected motor load, or the first kW of other permanently connected electric equipment); plus \$0.50 net per month per horsepower of motors with individual capacities of

(Continued)

Issued	November	8	1977	Effective	November	28	1977
	Month	Day	Year		Month	Day	Year
Oklahoma Corporation Commission							
Rates Authorized by	134529		26003		9-30-77		
	(Order No.)		(J. E. No.)		(Date of Letter)		
Issued by	J. G. Harlow, Jr.			President			
	(Name of Officer)			(Title)			
Oklahoma City, Oklahoma							
(Address of Officer)							

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

C-1

CODE NO 06

Commercial Rate

COM

(Continued)

over one-half horsepower and per kW of other permanently connected electric equipment. However, the minimum monthly bill for consumers served in a non-urban area shall never be less than \$4.99 plus any applicable fuel cost adjustment. Non-urban area refers to a place outside the urban rate district of any city or town, or in a locality where the density of population is less than that ordinarily encountered in urban or suburban districts.

Horsepower of apparatus connected will be based on manufacturer's rating; if manufacturer's rating is expressed in kilowatts, 750 watts will be considered as the equivalent of one horsepower; if manufacturer's rating is expressed in volts and amperes, 1000 volt-amperes will be considered as the equivalent of one horsepower.

The Company shall specify a larger minimum monthly bill, calculated in accordance with the Company's Allowable Expenditure Formula in its Terms and Conditions of Service on file with and approved by the Commission, when necessary to justify the investment required to provide service.

FUEL COST ADJUSTMENT: The rate as stated above is based upon an average cost of \$1.00 per million Btu for the cost of fuel burned at the Company's thermal generating plants. The monthly bill as calculated under the above rate shall be increased or decreased for each kWh consumed by an amount computed in accordance with the following formula:

$$F.A. = A \times \frac{B}{10^6} \times C \times \frac{1}{1-D}$$

Where F.A. = The fuel cost adjustment factor (expressed in dollars per kWh) to be applied per kWh consumed.

A = The weighted average Btu/kWh for net generation from the Company's thermal plants during the second calendar month preceding the end of the billing period for which the kWh usage is billed.

B = The amount by which the average cost of fuel per million Btu during the second calendar month preceding the end of the billing period for which the kWh usage is billed exceeds or is less than \$1.00 per million Btu. Any credits, refunds or allowances on previously purchased fuel, received by the Company from any source shall be deducted from the cost of fuel before calculating "B" each month.

(Continued)

Issued	February	3	1978	Effective	February	16	1978
	Month	Day	Year		Month	Day	Year
Rates Authorized by	Oklahoma Corporation Commission						
	137677	26219	1-25-78				
	(Order No.)	(J. E. No.)	(Cause No.)	(Date of Letter)			
Issued by	J. G. Harlow, Jr.			President			
	(Name of Officer)			(Title)			
	Oklahoma City, Oklahoma						
	(Address of Officer)						

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

C-1

CODE NO 06

Commercial Rate

COM

(Continued)

- C = The ratio (expressed decimally) of the total net generation from all the Company's thermal plants during the second calendar month preceding the end of the billing period for which the kWh usage is billed to the total net generation from all the Company's plants including hydro generation owned by the Company, or kWh produced by hydro generation and purchased by the Company, during the same period.
- D = A loss factor, which is the ratio (expressed decimally) of kWh losses (total kWh losses less losses of 2.5% associated with off-system sales) to net system input (total system input less total kWh in off-system sales) for the year ending December 31st preceding. This ratio shall be based on information as reported by the Company to the Federal Power Commission in its Annual Report Form No. 1 and upon a detailed report of off-system sales to the Commission. This ratio will be used for twelve months and will be changed beginning with the 1st of April each year.

FRANCHISE PAYMENT: Pursuant to Order No. 110730 and Rule 54(a) of Order No. 104932 of the Corporation Commission of Oklahoma, franchise taxes or payments (based upon a per cent of gross revenue) in excess of 2% required by a franchise or other ordinance approved by the qualified electors of a municipality, to be paid by the Company to the municipality, will be added pro rata as a percentage of charges for electric service, as a separate item, to the bills of all consumers receiving service from the Company within the corporate limits of the municipality exacting the said tax or payment.

TERM: Open order. Seasonal changes to other rate schedules are prohibited. The Company may require a contract for a year or longer, subject also to special minimum guarantees, which may be necessary in cases warranted by special circumstances or unusually large investments by the Company. Such special minimum guarantees shall be calculated in accordance with the Company's Allowable Expenditure Formula in its Terms and Conditions of Service filed with and approved by the Commission.

Issued	February	3	1978	Effective	February	16	1978
	Month	Day	Year		Month	Day	Year
Oklahoma Corporation Commission							
Rates Authorized by	137677		26219		1-25-78		
	(Order No.)		(J. E. No.)		(Date of Letter)		
Issued by	J. G. Harlow, Jr.			President			
	(Name of Officer)			(Title)			
Oklahoma City, Oklahoma							
(Address of Officer)							

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

PL-1

CODE NO 30

Power and Light Rate

PL

EFFECTIVE IN: All territory served.

AVAILABILITY: Power and light service. Alternating current. Service will be rendered at one location at one voltage. No resale, breakdown, auxiliary or supplementary service permitted.

RATE: Demand Charge

On-Peak Season (Bills for energy used during meter reading periods ending June 1 through October 31 of any year.)

\$2.20 per kW per month of billing demand.

Off-Peak Season (Bills for energy used during meter reading periods ending November 1 of any year through May 31 of the succeeding year.)

\$1.55 per kW per month of billing demand.

Energy Charge

First 15,000 kWh per month @ 2.968¢ per kWh

Next 17,500 kWh per month @ 2.328¢ per kWh

Next 37,500 kWh per month @ 1.897¢ per kWh

All Additional kWh per month @ 1.641¢ per kWh

LATE PAYMENT CHARGE: A late payment charge in an amount equal to one and one-half per cent (1 1/2%) of the total amount due on each monthly bill as calculated under the above rate will be added if the bill is not paid on or before the due date stated on the bill. The due date shall be ten (10) days after the bill is mailed.

MINIMUM BILL: The minimum monthly bill shall be the demand charge plus the energy charge including any applicable fuel cost adjustment, as computed under the above schedule. The Company shall specify a larger minimum monthly bill, calculated in accordance with the Company's Allowable Expenditure Formula in its Terms and Conditions of Service on file with and approved by the Commission, when necessary to justify the investment required to provide service.

DETERMINATION OF MAXIMUM DEMAND: The consumer's maximum demand shall be the maximum rate at which energy is used for any period of 15 consecutive minutes of the month for which the bill is rendered as shown by the Company's demand meter. In the event a consumer taking service under this rate has a demand meter with an interval greater than 15 minutes, the Company shall have a reasonable time to change the metering device.

DETERMINATION OF BILLING DEMAND: The billing demand upon which the demand charge is based shall be the maximum demand as determined above

(Continued)

Issued November 8 1977		Bills rendered on and after Effective November 28 1977	
Month	Day	Month	Day
Oklahoma Corporation Commission			
Rates Authorized by 134529		26003 9-30-77	
(Order No.)		(Cause No.) (Date of Letter)	
Issued by J. G. Harlow, Jr.		President	
(Name of Officer)		(Title)	
Oklahoma City, Oklahoma			
(Address of Officer)			

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

PL-1

CODE NO 30

Power and Light Rate

PL

(Continued)

corrected for power factor, as set forth under power factor clause; provided, that no billing demand shall be considered as less than 65% of the highest On-Peak season billing demand previously determined during the 12 months ending with the current month and shall never be less than 10 kW.

POWER FACTOR CLAUSE: The consumer shall at all times take and use power in such manner that the power factor shall be as nearly 100% as possible, but when the average power factor as determined by continuous measurement of lagging reactive kilovoltampere hours is less than 80%, the billing demand shall be determined by multiplying the maximum demand, shown by the demand meter for the billing period, by 80 and dividing the product thus obtained by the actual average power factor expressed in per cent. The Company may, at its option, use for adjustment the power factor as determined by test during periods of normal operation of the consumer's equipment instead of the average power factor.

FUEL COST ADJUSTMENT: The rate as stated above is based upon an average cost of \$1.00 per million Btu for the cost of fuel burned at the Company's thermal generating plants. The monthly bill as calculated under the above rate shall be increased or decreased for each kWh consumed by an amount computed in accordance with the following formula:

$$F.A. = A \times \frac{B}{10^6} \times C \times \frac{1}{1-D}$$

Where F. A. = The fuel cost adjustment factor (expressed in dollars per kWh) to be applied per kWh consumed.

A = The weighted average Btu/kWh for net generation from the Company's thermal plants during the second calendar month preceding the end of the billing period for which the kWh usage is billed.

B = The amount by which the average cost of fuel per million Btu during the second calendar month preceding the end of the billing period for which the kWh usage is billed exceeds or is less than \$1.00 per million Btu. Any credits, refunds or allowances on previously purchased fuel, received by the Company from any source, shall be deducted from the cost of fuel before calculating "B" each month.

(Continued)

Issued	February	3	1978	Effective	February	16	1978
	Month	Day	Year		Month	Day	Year
Oklahoma Corporation Commission							
Rates Authorized by	137677		26219		1-25-78		
	(Order No.)		(J. E. No.)		(Date of Letter)		
Issued by	J. G. Harlow, Jr.			President			
	(Name of Officer)			(Title)			
Oklahoma City, Oklahoma							
(Address of Officer)							

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

PL-1

CODE NO 30

Power and Light Rate

PL

(Continued)

- C = The ratio (expressed decimally) of the total net generation from all the Company's thermal plants during the second calendar month preceding the end of the billing period for which the kWh usage is billed to the total net generation from all the Company's plants including hydro generation owned by the Company, or kWh produced by hydro generation and purchased by the Company, during the same period.
- D = A loss factor, which is the ratio (expressed decimally) of kWh losses (total kWh losses less losses of 2.5% associated with off-system sales) to net system input (total system input less total kWh in off-system sales) for the year ending December 31st preceding. This ratio shall be based on information as reported by the Company to the Federal Power Commission in its Annual Report Form No. 1 and upon a detailed report of off-system sales to the Commission. This ratio will be used for twelve months and will be changed beginning with the 1st of April each year.

FRANCHISE PAYMENT: Pursuant to Order No. 110730 and Rule 54(a) of Order No. 104932 of the Corporation Commission of Oklahoma, franchise taxes or payments (based upon a per cent of gross revenue) in excess of 2% required by a franchise or other ordinance approved by the qualified electors of a municipality, to be paid by the Company to the municipality, will be added pro rata as a percentage of charges for electric service, as a separate item, to the bills of all consumers receiving service from the Company within the corporate limits of the municipality exacting the said tax or payment.

DISTRIBUTION VOLTAGE DISCOUNT: The rate as stated above is based on service delivered at secondary voltage. Secondary voltage shall mean any available standard voltage of the Company less than 2,000 volts.

When electric service is supplied by the Company to the consumer at a distribution voltage by either of the following methods, a discount of \$0.36 per kW of Billing Demand shall be allowed:

- (1) At a prevailing distribution voltage through existing distribution facilities when such facilities have sufficient capacity; or

(Continued)

Issued	February	3	1978	Effective	February	16	1978
	Month	Day	Year		Month	Day	Year
Oklahoma Corporation Commission							
Rates Authorized by	137677		26219		1-25-78		
	(Order No.)		(J. E. No.)		(Date of Letter)		
Issued by	J. G. Harlow, Jr.			President			
	(Name of Officer)			(Title)			
	Oklahoma City, Oklahoma						
	(Address of Officer)						

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA

DIVISION

STANDARD RATE SCHEDULE

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CODE NO

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Power and Light Rate

PL

(Continued)

- (2) By means of not more than one transformation from a prevailing transmission voltage facility to a distribution voltage. (Distribution voltage shall mean a standard Company voltage greater than 2 kV but not exceeding 30 kV.)

Prevailing distribution voltage shall normally mean 12.47 kV or greater, but not exceeding 30 kV. Where distribution voltages of 12.47 kV through 30 kV are not available, and a nominal voltage greater than 2 kV is available, this voltage shall be considered the prevailing distribution voltage.

Prevailing transmission voltage shall normally mean 69 kV or greater, except where 69 kV or greater is not available, but a nominal voltage greater than 30 kV is available, the latter shall be considered the prevailing transmission voltage.

If the Company chooses to meter on the load side of the consumer's transformers, the kWh billed shall be increased by the amount of the transformer losses calculated as follows:

1% of the total kVA rating of the consumer's transformers
times 730 hours.

TERM: Contracts under this schedule shall be for not less than one year, but longer contracts subject also to special minimum guarantees may be necessary in cases warranted by special circumstances or unusually large investments by the Company. Such special minimum guarantees shall be calculated in accordance with the Company's Allowable Expenditure Formula in its Terms and Conditions of Service on file with and approved by the Commission.

Bills rendered on and after

Issued November 8 1977 Effective November 28 1977
Month Day Year Month Day Year

Rates Authorized by Oklahoma Corporation Commission
134529 26003 9-30-77
(Order No.) (J. E. No.) (Cause No.) (Date of Letter)

Issued by J. G. Harlow, Jr. President
(Name of Officer) (Title)

Oklahoma City, Oklahoma
(Address of Officer)

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

LPL-1

CODE NO 35

Large Power and Light Rate

LPL

EFFECTIVE IN: All territory served.

AVAILABILITY: Large power consumers. Alternating current. Service will be rendered at one location at one voltage. No resale, breakdown, auxiliary or supplementary service permitted.

RATE: Demand Charge

First

400 kW of billing demand @\$2. 24 per kW per month

All Additional

kW of billing demand @\$1. 64 per kW per month

Energy Charge

First

100, 000 kWh per month @1. 958¢ per kWh

Next

1, 900, 000 kWh per month @1. 553¢ per kWh

All Additional

kWh per month @1. 484¢ per kWh

LATE PAYMENT CHARGE: A late payment charge in an amount equal to one and one-half per cent (1 1/2%) of the total amount due on each monthly bill as calculated under the above rate will be added if the bill is not paid on or before the due date stated on the bill. The due date shall be ten (10) days after the bill is mailed.

MINIMUM BILL: The minimum monthly bill shall be the demand charge plus the energy charge including any applicable fuel cost adjustment, as computed under the above schedule. The Company shall specify a larger minimum bill, calculated in accordance with the Company's Allowable Expenditure Formula in its Terms and Conditions of Service on file with and approved by the Commission, when necessary to justify the investment required to provide service.

DETERMINATION OF MAXIMUM DEMAND: The consumer's maximum demand shall be the maximum rate at which energy is used for any period of 15 consecutive minutes of the month for which the bill is rendered as shown by the Company's demand meter. In the event a consumer taking service under this rate has a demand meter with an interval greater than 15 minutes, the Company shall have a reasonable time to change the metering device.

DETERMINATION OF BILLING DEMAND: The billing demand upon which the demand charge is based shall be the maximum demand as determined above corrected for power factor, as set forth under power factor clause, provided, that no billing demand shall be considered as less than 65% of the highest billing demand previously determined during the 12 months ending with the current month, and the billing demand shall never be less than 400 kW.

(Continued)

Issued November 8 1977	Bills rendered on and after		
Month Day Year	Effective November 28 1977	Month Day Year	
Oklahoma Corporation Commission			
Rates Authorized by 134529	26003	9-30-77	
(Order No.)	(J. E. No.)	(Cause No.)	(Date of Letter)
Issued by J. G. Harlow, Jr.	President		
(Name of Officer)	(Title)		
Oklahoma City, Oklahoma			
(Address of Officer)			

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

LPL-1

CODE NO 35

Large Power and Light Rate

LPL

(Continued)

POWER FACTOR CLAUSE: The standard power factor upon which this rate is based is a monthly average power factor of 80%. The average monthly power factor shall be determined by instruments designed to record power factor graphically, by the use of reactive component meter, or by other suitable instruments at the option of the Company. When the reactive component meter is used the monthly average power factor shall be calculated from the monthly use of kilowatt-hours "A" as obtained from the integrating watt-hour meter and the monthly use of lagging reactive kilovoltampere hours "B" as obtained from the reactive component meter by the following formula:

Monthly average power factor equals "A" divided by
 the square root of ("A" squared plus "B" squared).

When the average monthly power factor is more than 75% and less than 85%, no power factor adjustment in billing demand shall be made. Whenever the average monthly power factor is 75% or less or 85% or more, the monthly billing demand shall equal the measured maximum demand multiplied by 80 and divided by the monthly average power factor expressed in per cent.

FUEL COST ADJUSTMENT: The rate as stated above is based upon an average cost of \$1.00 per million Btu for the cost of fuel burned at the Company's thermal generating plants. The monthly bill as calculated under the above rate shall be increased or decreased for each kWh consumed by an amount computed in accordance with the following formula:

$$F.A. = A \times \frac{B}{10^6} \times C \times \frac{1}{1-D}$$

Where F.A. = The fuel cost adjustment factor (expressed in dollars per kWh) to be applied per kWh consumed.

A = The weighted average Btu/kWh for net generation from the Company's thermal plants during the second calendar month preceding the end of the billing period for which the kWh usage is billed.

(Continued)

Issued	February	3	1978	Effective	February	16	1978
	Month	Day	Year		Month	Day	Year
Oklahoma Corporation Commission							
Rates Authorized by	137677		26219		1-25-78		
	(Order No.)		(J. E. No.)		(Date of Letter)		
Issued by	J. G. Harlow, Jr.			President			
	(Name of Officer)			(Title)			
Oklahoma City, Oklahoma							
(Address of Officer)							

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

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Large Power and Light Rate

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(Continued)

- B = The amount by which the average cost of fuel per million Btu during the second calendar month preceding the end of the billing period for which the kWh usage is billed exceeds or is less than \$1.00 per million Btu. Any credits, refunds or allowances on previously purchased fuel, received by the Company from any source shall be deducted from the cost of fuel before calculating "B" each month.
- C = The ratio (expressed decimally) of the total net generation from all the Company's thermal plants during the second calendar month preceding the end of the billing period for which the kWh usage is billed to the total net generation from all the Company's plants including hydro generation owned by the Company, or kWh produced by hydro generation and purchased by the Company, during the same period.
- D = A loss factor, which is the ratio (expressed decimally) of kWh losses (total kWh losses less losses of 2.5% associated with off-system sales) to net system input (total system input less total kWh in off-system sales) for the year ending December 31st preceding. This ratio shall be based on information as reported by the Company to the Federal Power Commission in its Annual Report Form No. 1 and upon a detailed report of off-system sales to the Commission. This ratio will be used for twelve months and will be changed beginning with the 1st of April each year.

FRANCHISE PAYMENT: Pursuant to Order No. 110730 and Rule 54(a) of Order No. 104932 of the Corporation Commission of Oklahoma, franchise taxes or payments (based upon a per cent of gross revenue) in excess of 2% required by a franchise or other ordinance approved by the qualified electors of a municipality, to be paid by the Company to the municipality, will be added pro rata as a percentage of charges for electric service, as a separate item, to the bills of all consumers receiving service from the Company within the corporate limits of the municipality exacting the said tax or payment.

(Continued)

Issued	February	3	1978	Effective	February	16	1978
	Month	Day	Year		Month	Day	Year
Oklahoma Corporation Commission							
Rates Authorized by	137677			26219		1-25-78	
	(Order No.)		(J. E. No.)	(Cause No.)		(Date of Letter)	
Issued by	J. G. Harlow, Jr.			President			
	(Name of Officer)			(Title)			
Oklahoma City, Oklahoma							
(Address of Officer)							

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

LPL-1

CODE NO 35

Large Power and Light Rate

LPL

(Continued)

DELIVERY VOLTAGE SURCHARGE OR DISCOUNT: (a) The rate as stated above shall be applicable when electric service is supplied by the Company to the consumer at a distribution voltage by either of the following methods:

- (1) At a prevailing distribution voltage through existing distribution facilities when such facilities have sufficient capacity; or
- (2) By means of not more than one transformation from a prevailing transmission voltage facility to a distribution voltage. (Distribution voltage shall mean a standard Company voltage greater than 2 kV but not exceeding 30 kV.)

(b) When power and energy are delivered by the Company to the consumer at a voltage less than a prevailing distribution voltage or at a distribution voltage made available by a method other than as stated in paragraph (a) above, a transformation surcharge shall be included in the monthly billing calculated as follows for each kW of Billing Demand:

Transformation surcharge @ \$0.36 per kW per month.

(c) When power and energy are delivered by the Company to the consumer at the prevailing transmission voltage of the Company's existing system, a transmission voltage service discount shall be included in the monthly billing calculated as follows for each kW of Billing Demand:

Transmission voltage service discount @ \$0.45 per kW per month.

(d) Prevailing distribution voltage shall normally mean 12.47 kV or greater, but not exceeding 30 kV. Where distribution voltages of 12.47 kV through 30 kV are not available, and a nominal voltage greater than 2 kV is available, this voltage shall be considered the prevailing distribution voltage.

Prevailing transmission voltage shall normally mean 69 kV or greater, except where 69 kV or greater is not available, but a nominal voltage greater than 30 kV is available, the latter shall be considered the prevailing transmission voltage.

(Continued)

Issued November 8 1977			Bills rendered on and after Effective November 28 1977		
Month	Day	Year	Month	Day	Year
Oklahoma Corporation Commission					
Rates Authorized by		134529	26003		9-30-77
		(Order No.)	(Cause No.)		(Date of Letter)
Issued by		J. G. Harlow, Jr.	President		
		(Name of Officer)	(Title)		
Oklahoma City, Oklahoma					
(Address of Officer)					

OKLAHOMA GAS AND ELECTRIC COMPANY

OKLAHOMA DIVISION

STANDARD RATE SCHEDULE

LPL-1

CODE NO

35

Large Power and Light Rate

LPL

(Continued)

(e) If the Company chooses to install its metering equipment on the load side of the consumer's transformers, the kWh billed shall be increased by the amount of the transformer losses calculated as follows:

1% of the total kVA rating of the consumer's transformers
times 730 hours.

TERM: Contracts under this schedule shall be for not less than one year, but longer contracts subject also to special minimum guarantees may be necessary in cases warranted by special circumstances or unusually large investments by the Company. Such special minimum guarantees shall be calculated in accordance with Company's Allowable Expenditure Formula in its Terms and Conditions of Service on file with and approved by the Commission.

Bills rendered on and after

Issued November 8 1977 Effective November 28 1977
Month Day Year Month Day Year

Oklahoma Corporation Commission

Rates Authorized by 134529 26003 9-30-77
(Order No.) (J. E. No.) (Cause No.) (Date of Letter)

Issued by J. G. Harlow, Jr. President
(Name of Officer) (Title)

Oklahoma City, Oklahoma
(Address of Officer)

APPENDIX C

Program Listing

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00010      COMMON NOPR(100),MKW(100),MRUN(100),DMND(100),HOPT(100),
00020      & NENGY(500),KWH(100),ALOAD(100),RTEMP,ABTU,BBTU,OHRA,
00030      & OHRB,ATEMP,BTEMP,AHR,BHR,ACOST,BCOST
00040      COMMON /USER/ DCOST,DMAND,VOLT,AMP,PPF,DPF,MACH(100),
00050      & LOAD(100),NMACH,DLIM,NUBR,DMNN(100),MACC(100)
00060      COMMON /USER1/ FACH,DACH,HOTOT,HOTIN,COOLOT,COOLIN,
00070      & FANHRA,FANHRE,FHP
00080      REAL KW,KVA,KVAR,KVAR2
00090      WRITE (6,1002)
00100 1002  FORMAT (//////' *****'/' ENERGY SIMULATOR'/
00110      &' *****')
00120      WRITE (6,999)
00130 999  FORMAT(//////)
00140      WRITE (6,1)
00150 1    FORMAT (' THIS PROGRAM ALLOWS MANAGERS TO TEST THE COST',
00160      &' EFFECTIVENESS OF THEIR ENERGY'/' SAVING IDEAS. THE ',
00170      &' COMPUTER WILL PROMPT THE USER AS NECESSARY.'////////)
00180 1000 DCOST=2.00
00190      DMAND=200
00200      RTEMP=72
00210      ABTU=60000
00220      BBTU=30000
00230      OHRA=1800
00240      OHRB=1200
00250      ATEMP=68
00260      BTEMP=78
00270      AHR=10
00280      BHR=10
00290      VOLT=440
00300      ACOST=.0000016
00310      BCOST=.000004
00320      AMP=500
00330      PPF=.5
00340      DPF=.8
00350      FLAG=0
00360      NMACH=5
00370      NUBR=0
00380      ALOAD(1)=.7
00390      ALOAD(2)=.8
00400      ALOAD(3)=.7
00410      ALOAD(4)=.7
00420      ALOAD(5)=.5
00430      DLIM=100
00440      DO 50 K=1,NMACH
00450      MRUN(K)=0
00460      MKW(K)=0
00470      NOPR(K)=0
00480      NENGY(K)=0
00490 50   CONTINUE
00500      MACH(1)=50
00510      MACH(2)=50
00520      MACH(3)=75
00530      MACH(4)=100
00540      MACH(5)=100
00550      FACH=12500
00560      DACH=6250
00570      HOTOT=40
00580      HOTIN=72
00590      COOLOT=80
00600      COOLIN=72
00610      FANHRA=1800
00620      FANHRE=1200
00630      FHP=10

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00660      &' ENTER "1" ; HOWEVER IF YOU WISH TO STOP THE ',
00670      &' SIMULATION ENTER "0",. '///)
00680      READ (5,*) I
00690      IF (I.NE.1) GO TO 1001
00700      WRITE (6,3)
00710 3      FORMAT (' YOU DO WANT TO SELECT AN ENERGY SAVING IDEA - ',
00720      &' CORRECT? ENTER "1" - YES "0" - NO, '///)
00730      READ (5,*) J
00740      IF (J.NE.1) GO TO 1000
00750 900    WRITE (6,4)
00760 4      FORMAT (' THE FOLLOWING IS A LIST OF ENERGY SAVING IDEAS ',
00770      &' PRESENTED ON THIS PROGRAM'/' ENTER THE NUMBER BESIDE ',
00780      &' THE APPROPRIATE ENERGY IDEA, '///)
00790      WRITE (6,5)
00800 5      FORMAT (' 1--POWER FACTOR ANALYSIS'/' 2--DEMAND ',
00810      &' CONTROLLER'/' 3--TEMPERATURE CONTROL'/' 4--VENTILATION ',
00811      &' CONTROL'///)
00820      READ (5,*) KK
00830      GO TO (200,300,400,500),KK
00840      GO TO 1000
00850 200    CALL PFACTR
00860      GO TO 1000
00870 300    CALL DEMAND
00880      GO TO 1000
00890 400    CALL TEMPT
00900      GO TO 1000
00910 500    CALL VENT
00920      GO TO 1000
00930 1001   STOP
00940      END
00950      SUBROUTINE PFACTR
00960      COMMON NOPR(100),MKW(100),MRUN(100),DMND(100),HOPT(100),
00970      & NENGY(500),KWH(100),ALOAD(100),RTEMP,ABTU,BBTU,OHRA,
00980      & OHRB,ATEMP,BTEMP,AHR,BHR,ACOST,BCOST
00990      COMMON /USER/ DCOST,DMAND,VOLT,AMP,PPF,DPF,MACH(100),
01000      & LOAD(100),NMACH,DLIM,NUBR,DMNN(100),MACC(100)
01010      COMMON /USER1/ PACH,DACH,HOTOT,HOTIN,COOLOT,COOLIN,
01020      & FANHRA,FANHRB,FHP
01030      REAL KW,KVA,KVAR,KVAR2
01040      WRITE (6,7)
01050 7      FORMAT (////////' *****'/' POWER FACTOR',
01060      &' ANALYSIS'/' *****'///)
01070      WRITE (6,202)
01080 202    FORMAT (///' A MEDIUM SIZED METAL FABRICATING PLANT IN ',
01090      &' PERRY, OKLAHOMA UTILIZES A LARGE '//' NUMBER OF OVERLY ',
01100      &' SIZED INDUCTION MOTORS AND WELDERS. LIGHTING IS ',
01110      &' FURNISHED '//' BY SEVERAL HUNDRED EIGHT FOOT FLUORESCENT',
01120      &' LIGHTS. AT THE PRESENT TIME, THE '//' FACILITY IS ',
01130      &' PAYING A PENALTY FOR BAD POWER FACTOR AND IS ',
01140      &' CONSIDERING CAPACITOR '//' PLACEMENT ON THE MAIN ',
01150      &' FEEDER LINE.'///)
01160 1      WRITE (6,2)
01170 2      FORMAT (' DO YOU WISH TO RUN POWER FACTOR? ',
01180      &' ENTER "1" - YES "0" - NO'///)
01190      READ (5,*) I
01200      IF (I.NE.1) RETURN
01210      WRITE (6,9)
01220 9      FORMAT (' DO YOU WISH TO SEE AN EXAMPLE?',
01230      &' ENTER "1" - YES "0" - NO, '///)
01240      READ (5,*) I
01250      IF (I.NE.0) GO TO 156
01260      WRITE (6,10)
01270 10     FORMAT (' ENTER DATA AS REQUESTED BY COMPUTER IF ',
01280      &' NECESSARY TO CHANGE, '//' IMPORTANT!!'/' WHEN ENTERING',

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01310 11      WRITE (5,11)
01310 11      FORMAT (' DEMAND CHARGE-$2.00 PER KW PER MONTH'// DO YOU ',
01320      &' WISH TO CHANGE? ENTER "1" - YES "0" - NO.'//)
01330      READ (5,*) II
01340      IF (II.NE.1) GO TO 101
01350      READ (5,*) DCOST
01360      WRITE(6,20) DCOST
01370 20      FORMAT (F7.2)
01380      WRITE (6,30)
01390 30      FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
01400      READ (5,*) III
01410      IF (III.NE.1) GO TO 201
01420 101     WRITE (6,12)
01430 12      FORMAT (' BILLED KW DEMAND - 100 KW'// DO YOU WISH TO ',
01440      &' CHANGE? ENTER "1" - YES "0" - NO.'//)
01450      READ (5,*) JJ
01460      IF (JJ.NE.1) GO TO 102
01470      READ (5,*) DMAND
01480      WRITE (6,21) DMAND
01490 21      FORMAT (F7.2)
01500      WRITE (6,31)
01510 31      FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
01520      READ (5,*) JJJ
01530      IF (JJJ.NE.1) GO TO 101
01540 102     WRITE (6,13)
01550 13      FORMAT (' LINE VOLTAGE - 220 VOLTS'// DO YOU WISH TO ',
01560      &' CHANGE? ENTER "1" - YES "0" - NO.'//)
01570      READ (5,*) KK
01580      IF (KK.NE.1) GO TO 103
01590      READ (5,*) VOLT
01600      WRITE (6,22) VOLT
01610 22      FORMAT (F7.2)
01620      WRITE (6,32)
01630 32      FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
01640      READ (5,*) KKK
01650      IF (KKK.NE.1) GO TO 102
01660 103     WRITE (6,14)
01670 14      FORMAT (' LINE AMPERAGE - 80 AMPS'// DO YOU WISH TO ',
01680      &' CHANGE? ENTER "1" - YES "0" - NO.'//)
01690      READ (5,*) LL
01700      IF (LL.NE.1) GO TO 104
01710      READ (5,*) AMP
01720      WRITE (6,23) AMP
01730 23      FORMAT (F7.2)
01740      WRITE (6,33)
01750 33      FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
01760      READ (5,*) MMM
01770      IF (MMM.NE.1) GO TO 103
01780 104     WRITE (6,15)
01790 15      FORMAT (' PRESENT POWER FACTOR - .5'// DO YOU WISH TO ',
01800      &' CHANGE? ENTER "1" - YES "0" - NO.'//)
01810      READ (5,*) MM
01820      IF (MM.NE.1) GO TO 105
01830      READ (5,*) PPF
01840      WRITE (6,24) PPF
01850 24      FORMAT (F7.2)
01860      WRITE (6,40)
01870 40      FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
01880      READ (5,*) NNN
01890      IF (NNN.NE.1) GO TO 104
01900 105     WRITE (6,16)
01910 16      FORMAT (' DESIRED POWER FACTOR - .80'// DO YOU WISH TO ',
01920      &' CHANGE? ENTER "1" - YES "0" - NO.'//)
01930      READ (5,*) NN
01940      IF (NN.NE.1) GO TO 156

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01970 25  FORMAT (F7.2)
01980      WRITE (6,41)
01990 41  FORMAT (' CORRECT? ENTER "1" - YES "0" - NO. '//)
02000      READ (5,*) LLL
02010      IF (LLL.NE.1) GO TO 105
02020 156  PCOST=(DMAND*.8/PPF)*DCOST
02030      KW=(VOLT/1000)*AMP*PPF*1.732
02040      KVAR=SQRT(((VOLT/1000)*AMP*1.732)**2 - KW**2)
02050      KVA=KW/DPF
02060      KVAR2=SQRT(((KVA**2) - (KW**2)))
02070      TKVAR=KVAR - KVAR2
02080      NKVAR=TKVAR + .5
02090      CCOST=NKVAR*18.50
02100      WRITE (6,43)
02110 43  FORMAT(///)
02120      WRITE(6,39)
02130 39  FORMAT (' THE PENALTY CHARGE IS CALCULATED USING A PERCENT',
02140      &' TAGE OF THE DEMAND CHARGE. '// POWER FACTORS GREATER ',
02150      &' THAN 0.8 WILL OFTEN YIELD A BONUS. THE CAPACITOR '//
02160      &' COST IS APPROXIMATELY $18.50 PER KVAR. '//)
02170      SAVE=(DMAND*.8/PPF - DMAND*.8/DPF)*2.00
02180      PBACK=CCOST/SAVE
02190      WRITE (6,17) PPF,PCOST,DPF,CCOST,PBACK
02200 17  FORMAT (' PRESENT POWER FACTOR -',F7.2,' MONTHLY PENALTY ',
02210      &' COST-$',F7.2,' DESIRED POWER FACTOR -',F7.2,' CAPACI',
02220      &' TOR COST-$',F7.2,' PAYBACK - ',F7.2,' MONTHS')
02230      WRITE (6,19)
02240 19  FORMAT (' IF YOU HAVE ANY QUESTIONS SEE MANUAL PAGE',
02250      &' , '////////)
02260      GO TO 1
02270      END
02280      SUBROUTINE DEMAND
02290      COMMON NOPR(100),MKW(100),MRUN(100),DMND(100),HOPT(100),
02300      & NENGY(500),KWH(100),ALOAD(100),RTEMP,ABTU,BBTU,OHRA,
02310      & OHRB,ATEMP,BTEMP,AHR,BHR,ACOST,BCOST
02320      COMMON /USER/ DCOST,DMAND,VOLT,AMP,PPF,DPF,MACH(100),
02330      & LOAD(100),NMACH,DLIM,NUBR,DMNN(100),MACC(100)
02340      COMMON /USER1/ PACH,DACH,HOTOT,HOTIN,COOLOT,COOLIN,
02350      & FANHRA,FANHRB,FHP
02360      REAL KW,KVA,KVAR,KVAR2
02370      FLAG=0
02380      WRITE (6,1)
02390 1  FORMAT (////////' *****'// DEMAND CONTROLLER'/
02400      &' *****'////)
02410      WRITE (6,114)
02420 114  FORMAT (///' A MEDIUM SIZED JOB SHOP IN CENTRAL OKLAHOMA ',
02430      &' IS BILLED WITH A DEMAND PENALTY. '// THE FACILITY HAS ',
02440      &' A SERIES OF LARGE HORSEPOWER MOTORS WHICH ARE BEING '//
02450      &' CONTROLLED USING A SMALL MICROPROCESSOR. AS THE DEMAND ',
02460      &' APPROACHES THE '// LIMIT, THE MOTORS ARE MOMENTARILY ',
02470      &' SHUT OFF. DEMAND CHARGE IS $2.00 '// MULTIPLIED BY THE ',
02480      &' HIGHEST AVERAGE DEMAND. '//)
02490      FLAG=0
02500 111  DO 50 K=1,NMACH
02510      MRUN(K)=0
02520      MKW(K)=0
02530      NOPR(K)=0
02540      NENGY(K)=0
02550 50  CONTINUE
02560      MACH(1)=50
02570      MACH(2)=50
02580      MACH(3)=75
02590      MACH(4)=100
02600      MACH(5)=100

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02630 113  FORMAT (' DO YOU WISH TO RUN DEMAND CONTROLLER?',
02640      &' ENTER "1" - YES "0" - NO'//)
02650      READ (5,*) I
02660      IF (I.NE.1) RETURN
02670      WRITE (6,30)
02680 30    FORMAT(' DO YOU WISH AN EXAMPLE? ENTER "1" -YES "0" -NO',
02690      &' //)
02700      READ (5,*) I
02710      IF (I.NE.0) GO TO 500
02720 1000  WRITE (6,2)
02730 2    FORMAT (////' DO YOU WISH TO ENTER YOUR OWN DATA?',
02740      &' ENTER "1" - YES "0" - NO.'//)
02750      READ (5,*) I
02760      IF (I.NE.1) GO TO 510
02770      WRITE (6,3)
02780 3    FORMAT(' YOU DO WISH TO ENTER YOUR OWN DATA-CORRECT?',
02790      &' ENTER "1" - YES "0" - NO.'//)
02800      READ (5,*) J
02810      IF (J.NE.1) GO TO 1000
02820      WRITE (6,4)
02830 4    FORMAT (' ENTER DATA AS REQUESTED BY COMPUTER IF',
02840      &' NECESSARY TO CHANGE. '/' IMPORTANT!! '/' WHEN ENTERING',
02850      &' DECIMAL VALUES, PLACE ZERO BEFORE THE DECIMAL POINT'//)
02860 36    WRITE (6,35)
02870 35    FORMAT (' NUMBER OF MACHINES SIMULATED - 5'/' DO YOU WISH',
02880      &' TO CHANGE? ENTER "1" - YES "0" - NO.'//)
02890      READ (5,*) K
02900      IF (K.NE.1) GO TO 900
02910      READ (5,*) NMACH
02920      WRITE (6,5) NMACH
02930 5    FORMAT (I5)
02940      WRITE (6,7)
02950 7    FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
02960      READ (5,*) I
02970      IF (I.NE.1) GO TO 36
02980 900  WRITE (6,6)
02990 6    FORMAT (' MACHINE HORSEPOWERS- 50,50,75,100,100'/' DO YOU',
03000      &' WISH TO CHANGE ENTER "1" - YES "0" - NO.'//)
03010      READ (5,*) L
03020      IF (L.NE.1) GO TO 700
03030      READ (5,*) (MACH(I), I = 1,NMACH)
03040      WRITE (6,9) (MACH(I), I = 1,NMACH)
03050 9    FORMAT (100I5)
03060      WRITE (6,10)
03070 10   FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
03080      READ (5,*) M
03090      IF (M.NE.1) GO TO 900
03100 700  WRITE (6,11)
03110 11   FORMAT (' CORRESPONDING MOTOR LOADS - .7,.8,.7,.7,.5'/'
03120      &' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO.'//)
03130      READ (5,*) N
03140      IF (N.NE.1) GO TO 600
03150      READ (5,*) (ALOAD(I), I=1,NMACH)
03160      WRITE (6,13) (ALOAD(I), I=1,NMACH)
03170 13   FORMAT (100F5.2)
03180      WRITE (6,14)
03190 14   FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
03200      READ (5,*) I
03210      IF (I.NE.1) GO TO 700
03220 600  WRITE (6,19)
03230 19   FORMAT(' THE DEMAND LIMIT IS 100 KW'/' DO YOU WISH TO CHA',
03240      &' NGE? ENTER "1" - YES "0" - NO.'//)
03250      READ (5,*) I
03260      IF (I.NE.1) GO TO 800

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03290 20    FORMAT (F7.2)
03300      WRITE (6,22)
03310 22    FORMAT (' CORRECT? ENTER "1" - YES "0" - NO.'//)
03320      READ (5,*) I
03330      IF (I.NE.1) GO TO 600
03340 800    WRITE (6,40)
03350 40    FORMAT (' THE DEMAND COST IS $2.00/KW/MONTH'// DO YOU WISH',
03360      & ' TO CHANGE? ENTER "1" - YES "0" - NO.'//)
03370      READ (5,*) I
03380      IF (I.NE.1) GO TO 500
03390      READ (5,*) DCOST
03400      WRITE (6,41) DCOST
03410 41    FORMAT (F7.2)
03420      WRITE (6,42)
03430 42    FORMAT(' CORRECT? ENTER "1" - YES "0" - NO.'//)
03440      READ (5,*) I
03450      IF (I.NE.1) GO TO 800
03460 500    DO 510 I=1,NMACH
03470        MACC(I)=MACH(I)
03480        MACH(I)=MACH(I)*.746
03490 510    CONTINUE
03500      WRITE (6,21)
03510 21    FORMAT (' DO YOU WANT DEMAND CONTROL? ENTER "1" - YES',
03520      & ' "0" - NO.'//)
03530      READ (5,*) I
03540      IF (I.NE.1) GO TO 400
03550      IX=13471
03560      IY=58731
03570      N=0
03580      DO 1001 I=1,480
03590        N=N+1
03600        DO 999 J=1,NMACH
03610          CALL RANDU(IX,IY,RA)
03620          IX=IY
03630          IF (RA.LE. 0.5) GO TO 490
03640          NOPR(J)=1
03650          GO TO 999
03660 490    NOPR(J)=0
03670 999    CONTINUE
03680          CALL RANDU(IX,IY,RN)
03690          IX=IY
03700          NUM=INT(RN*FLOAT(NMACH)) + 1
03710          KW=0
03720          DO 998 K=NUM,NMACH
03730            KW=KW+MACH(K)*NOPR(K)
03740            IF (KW.LT.DLIM) GO TO 897
03750            KW=KW-MACH(K)*NOPR(K)
03760            GO TO 996
03770 897    MRUN(K)=MRUN(K) + 1*NOPR(K)
03780            MKW(K)=MKW(K) + MACH(K)
03790 998    CONTINUE
03800            NNN=NUM-1
03810            IF (NUM.EQ.1) GO TO 997
03820            DO 997 L=1,NNN
03830              KW=KW + MACH(L) * NOPR(L)
03840              IF(KW.LT.DLIM) GO TO 898
03850              KW=KW-MACH(L)*NOPR(L)
03860              GO TO 996
03870 898    MRUN(L)=MRUN(L) + 1*NOPR(L)
03880            MKW(L)=MKW(L)+MACH(L)
03890 997    CONTINUE
03900 996    NENGY(I)=KW
03910            IF (N.EQ.15) GO TO 991
03920            GO TO 1001

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03950      TKW=0
03960      NGO=I-14
03970      DO 990 NSUM=NGO,I
03980      TKW=NENGY(NSUM) + TKW
03990 990    CONTINUE
04000      DMND(NUBR )=TKW/15
04010 1001  CONTINUE
04020 100    N=1
04030      IFLAG=0
04040      NFLAG=0
04050      DO 253 I=1,32
04060      DMNN(I)=DMND(I)
04070 253    CONTINUE
04080 101    IF (N.EQ.32) GO TO 104
04090 102    IF (DMND(N).LT.DMND(N+1)) GO TO 103
04100      N=N+1
04110      GO TO 101
04120 103    TEMP=DMND(N)
04130      DMND(N)=DMND(N+1)
04140      DMND(N+1)=TEMP
04150      NFLAG=1
04160      N=N+1
04170      GO TO 101
04180 104    IF((NFLAG.EQ.0).AND.(IFLAG.EQ.0)) GO TO 105
04190      N=1
04200      IFLAG=0
04210      NFLAG=0
04220      GO TO 102
04230 105    WRITE (6,68)
04240 68     FORMAT (///' THE MOTOR HORSEPOWERS ARE'/)
04250      WRITE (6,69) (MACC(I),I=1,NMACH)
04260 69     FORMAT (100I5)
04270      IF (FLAG.EQ.1) GO TO 67
04280      WRITE (6,66) DLIM
04290 66     FORMAT (' THE DEMAND LIMIT IS',F7.2/)
04300 67     COST=DMND(1)*DCOST
04310      DO 106 K=1,NMACH
04320      WRITE (6,15) K,MRUN(K)
04330 15     FORMAT (' OPERATING TIME FOR MOTOR',I3,I5)
04340 106    CONTINUE
04350      DO 107 M=1,NMACH
04360      HOPT(M)=MRUN(M)/60
04370      KWH(M)=HOPT(M)*MACH(M)
04380 107    CONTINUE
04390      DO 108 K=1,NMACH
04400      WRITE(6,16) K,KWH(K)
04410 16     FORMAT (' TOTAL KILOWATT HOURS FOR MOTOR',I3,I5)
04420 108    CONTINUE
04430      WRITE (6,52) (DMNN(I), I=1,32)
04440 52     FORMAT (' THE AVERAGE DEMAND EACH FIFTEEN MINUTES IS  --'//,
04450      & 8F7.2,/8F7.2,/8F7.2,/8F7.2)
04460      WRITE (6,17) DMND(1),COST
04470 17     FORMAT (' THE MAXIMUM AVERAGE DEMAND IS ',F10.2/
04480      & ' THE TOTAL DEMAND CHARGE FOR THE MONTH IS ',F10.2)
04490      WRITE (6,53)
04500 53     FORMAT (' IF YOU HAVE ANY QUESTIONS, SEE MANUAL PAGE  .')
04510      WRITE (6,51)
04520 51     FORMAT (////////)
04530      GO TO 111
04540 400    FLAG=1
04550      WRITE (6,18)
04560 18     FORMAT (' THIS PROGRAM SIMULATES WORK PERIOD WITH NO',
04570      & ' DEMAND CONTROL.'//)
04580      IX=34527

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04610 DO 2001 I=1,480
04620 N=N+1
04630 DO 1999 J=1,NMACH
04640 CALL RANDU (IX,IY,RA)
04650 IX=IY
04660 IF (RA,LE. 0.5) GO TO 1490
04670 NOPR(J)=1
04680 GO TO 1999
04690 1490 NOPR(J)=0
04700 1999 CONTINUE
04710 CALL RANDU (IX,IY,RN)
04720 IX=IY
04730 NUMB=INT(RN*FLOAT(NMACH)) + 1
04740 KW=0
04750 DO 1998 K=NUMB,NMACH
04760 KW=KW+MACH(K)*NOPR(K)
04770 MRUN(K)=MRUN(K)+1*NOPR(K)
04780 MKW(K)=MKW(K)+MACH(K)*NOPR(K)
04790 1998 CONTINUE
04800 NNN=NUMB-1
04810 IF (NUMB,EQ.1) GO TO 1997
04820 DO 1997 L=1,NNN
04830 KW=KW+MACH(L)*NOPR(L)
04840 MRUN(L)=MRUN(L)+1*NOPR(L)
04850 MKW(L)=MKW(L)+MACH(K)*NOPR(L)
04860 1997 CONTINUE
04870 NENGY(I)=KW
04880 IF(N,EQ.15) GO TO 1991
04890 GO TO 2001
04900 1991 NUBR=NUBR+1
04910 N=0
04920 TKW=0
04930 NGO=I-14
04940 DO 1990 NSUM=NGO,I
04950 TKW=NENGY(NSUM)+TKW
04960 1990 CONTINUE
04970 DMND(NUBR)=TKW/15
04980 2001 CONTINUE
04990 GO TO 100
05000 END
05010 SUBROUTINE RANDU (IX,IY,YFL)
05020 IY=IX*65539
05030 IF (IY) 5,6,6
05040 5 IY=IY+2147483647+1
05050 6 YFL=IY
05060 YFL=YFL*.0000000004656613
05070 RETURN 11
05080 END
05090 SUBROUTINE TEMPT
05100 - COMMON NOPR(100),MKW(100),MRUN(100),DMND(100),HOFT(100),
05110 & NENGY(500),KWH(100),ALOAD(100),RTEMP,ABTU,BBTU,OHRA,
05120 & OHRB,ATEMP,BTEMP,AHR,BHR,ACOST,BCOST
05130 COMMON /USER/ DCOST,DMAND,VOLT,AMP,PPF,DPF,MACH(100),
05140 & LOAD(100),NMACH,ILIM,NUBR,DMNN(100),MACC(100)
05150 COMMON /USER1/ PACH,DACH,HOTOT,HOTIN,COOLOT,COOLIN,
05160 & FANHRA,FANHRB,FHP
05170 REAL KW,KVA,KVAR,KVAR2
05180 WRITE (6,1)
05190 1 FORMAT (//////' *****'// TEMPERATURE CONTROL'//
05200 &' *****'//)
05210 WRITE (6,114)
05220 114 FORMAT (' SUBSTANTIAL SAVINGS CAN BE REALIZED BY SIMPLY ',
05230 &' ADJUSTING THERMOSTAT SETTINGS,'// APPROXIMATELY 3% PER',
05240 &' DEGREE SETBACK AND 4% PER DEGREE SETUP FROM A '// BASE',

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05270 113  FORMAT (' DO YOU WISH TO RUN TEMPERATURE CONTROL? ',
05280      &' ENTER "1" - YES "0" - NO'//)
05290      READ (5,*) I
05300      IF (I.NE.1) RETURN
05310      WRITE (6,2)
05320 2      FORMAT (' DO YOU WISH TO SEE AN EXAMPLE? ENTER "1" - YES ',
05330      &' "0" - NO'//)
05340      READ (5,*) I
05350      IF (I.NE.0) GO TO 993
05360      WRITE (6,3)
05370 3      FORMAT (' DO YOU WISH TO ENTER YOUR DATA? ENTER "1" - YES',
05380      &' "0" - NO'//)
05390      READ (5,*) I
05400      IF (I.NE.1) GO TO 993
05410      WRITE (6,4)
05420 4      FORMAT (' ENTER DATA AS REQUESTED BY THE COMPUTER IF',
05430      &' NECESSARY TO CHANGE.'// 'IMPORTANT!!'// 'WHEN ENTERING',
05440      &' DECIMAL VALUES, PLACE ZERO BEFORE THE DECIMAL POINT'//)
05450 999      WRITE (6,5) RTEMP
05460 5      FORMAT (' THE PRESENT THERMOSTAT SETTING IS',F7.2,' F'//
05470      &' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO'//)
05480      READ (5,*) I
05490      IF (I.NE.1) GO TO 998
05500      READ (5,*) RTEMP
05510      WRITE (6,6) RTEMP
05520 6      FORMAT (F7.2)
05530      WRITE (6,7)
05540 7      FORMAT (' CORRECT? - ENTER "1" - YES "0" - NO'//)
05550      READ (5,*) I
05560      IF (I.NE.1) GO TO 999
05570 998      WRITE (6,8) ATEMP,BTEMP
05580 8      FORMAT (' THE SETBACK THERMOSTAT SETTING IS',F7.2,' F'//
05590      &' THE SET UP THERMOSTAT SETTING IS',F7.2,' F'//
05600      &' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO'//)
05610      READ (5,*) I
05620      IF (I.NE.1) GO TO 997
05630      READ (5,*) ATEMP,BTEMP
05640      WRITE (6,9) ATEMP,BTEMP
05650 9      FORMAT (2F7.2)
05660      WRITE (6,10)
05670 10      FORMAT (' CORRECT? - ENTER "1" - YES "0" - NO'//)
05680      READ (5,*) I
05690      IF (I.NE.1) GO TO 998
05700 997      WRITE (6,11) AHR,BHR
05710 11      FORMAT (' THE HOURS SETBACK ARE',F7.2/
05720      &' THE HOURS OF SET UP ARE',F7.2/
05730      &' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO'//)
05740      READ (5,*) I
05750      IF (I.NE.1) GO TO 996
05760      READ (5,*) AHR,BHR
05770      WRITE (6,12) AHR,BHR
05780 12      FORMAT (2F7.2)
05790      WRITE (6,13)
05800 13      FORMAT (' CORRECT? - ENTER "1" - YES "0" - NO'//)
05810      READ (5,*) I
05820      IF (I.NE.1) GO TO 997
05830 996      WRITE (6,23)
05840 23      FORMAT (' ***APPROXIMATELY ONE TON OF CONDITIONING=1 KWH',
05850      &' =10000 BTU***'//)
05860      WRITE (6,14) ABTU,BBTU
05870 14      FORMAT (' THE HEATING ENERGY INPUT IS ',F12.2,' BTU'//
05880      &' THE COOLING ENERGY INPUT IS',F12.2,' BTU'//
05890      &' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO'//)
05900      READ (5,*) I
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05930      WRITE (6,15) ABTU,BBTU
05940 15    FORMAT (2F7.2)
05950      WRITE (6,16)
05960 16    FORMAT (' CORRECT? - ENTER "1" - YES "0" - NO'//)
05970      READ (5,*) I
05980      IF (I.NE.1) GO TO 996
05990 995   WRITE (6,17) OHRA,OHRB
06000 17    FORMAT (' THE ESTIMATED SEASONAL HEATER OPERATING HOURS ',
06010      &' IS',F10.2/' THE ESTIMATED SEASONAL AIR CONDITIONING ',
06020      &' OPERATING HOURS IS',F10.2/' DO YOU WISH TO CHANGE?',
06030      &' ENTER "1" - YES "0" - NO'//)
06040      READ (5,*) I
06050      IF (I.NE.1) GO TO 994
06060      READ (5,*) OHRA,OHRB
06070      WRITE (6,18) OHRA,OHRB
06080 18    FORMAT (2F10.2)
06090      WRITE (6,19)
06100 19    FORMAT (' CORRECT? - ENTER "1" - YES "0" - NO'//)
06110      READ (5,*) I
06120      IF (I.NE.1) GO TO 995
06130 994   WRITE (6,20) ACOST,BCOST
06140 20    FORMAT (' THE BTU COST OF GAS IS APPROXIMATELY ',
06150      &' $1.60/KCF * KCF/1000000 BTU =',F12.8/
06160      &' THE BTU COST OF ELECTRICITY IS APPROXIMATELY',
06170      &' $0.04/KWH * KWH/10000 BTU =',F12.8
06180      &' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO'//)
06190      READ (5,*) I
06200      IF (I.NE.1) GO TO 993
06210      READ (5,*) ACOST,BCOST
06220      WRITE (6,21) ACOST,BCOST
06230 21    FORMAT (2F7.2)
06240      WRITE (6,22)
06250 22    FORMAT (' CORRECT? - ENTER "1" - YES "0" - NO'//)
06260      READ (5,*) I
06270      IF (I.NE.1) GO TO 994
06280 993   CONTINUE
06290      HEAT=ACOST*ABTU*OHRA
06300      HSAVE=(RTEMP-ATEMP)*(AHR/24)*0.03*HEAT
06310      COOL=BCOST*BBTU*OHRB
06320      CSAVE=(BTEMP-RTEMP)*(BHR/24)*0.04*COOL
06330      WRITE (6,24) RTEMP,ABTU,BBTU,OHRA,OHRB,ATEMP,BTEMP,AHR,BHR
06340      &,ACOST,BCOST
06350 24    FORMAT (/// THE ESTIMATED NORMAL THERMOSTAT SETTING ',
06360      &' IS ',F7.2,' F'// HEATING ENERGY INPUT IS ',F12.2,' BTU'/
06370      &' THE COOLING ENERGY INPUT IS',F12.2,' BTU'/
06380      &' THE OPERATING HOURS DURING THE HEATING SEASON ARE',
06390      &' F10.4/
06400      &' THE OPERATING HOURS DURING THE COOLING SEASON ARE',
06410      &' F10.4/
06420      &' THE DESIRED SETBACK TEMPERATURE IS',F7.2,' F'//
06430      &' THE DESIRED SET UP TEMPERATURE IS',F7.2,' F'//
06440      &' THE SETBACK TIME IS',F7.2,' HOURS PER DAY'//
06450      &' THE SET UP TIME IS',F7.2,' HOURS PER DAY'//
06460      &' THE HEATING COST IS $',F12.8,' PER BTU'//
06470      &' THE COOLING COST IS',F12.8,' PER BTU'////)
06480      WRITE (6,25) HEAT,HSAVE,COOL,CSAVE
06490 25    FORMAT (' THE HEATING COSTS PER YEAR ARE $',F7.2/
06500      &' THE POTENTIAL HEATING SAVINGS ARE $',F7.2//
06510      &' THE COOLING COSTS PER YEAR ARE $',F7.2/
06520      &' THE POTENTIAL SAVINGS ARE $',F7.2//)
06530      WRITE (6,26)
06540 26    FORMAT (' IF YOU HAVE ANY QUESTIONS SEE MANUAL PAGE .'////)
06550      GO TO 111
06560      END

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06590      & NENGY(500),KWH(100),ALOAD(100),RTEMP,ARTU,BBTU,OHRA,
06600      & OHRB,ATEMP,AHR,BHR,ACOST,BCOST
06610      COMMON /USER/ DCOST,DMAND,VOLT,AMP,PPF,DPF,MACH(100),
06620      & LOAD(100),NMACH,DLIM,NUBR,DMNN(100),MACC(100)
06630      COMMON /USER1/ PACH,DACH,HOTOT,HOTIN,COOLOT,COOLIN,
06640      & FANHRA,FANHRB,FHP
06650      REAL KW,KVA,KVAR,KVAR2
06651      BCOST=0.000004
06660      WRITE (6,1)
06670 1      FORMAT (//////' *****'// VENTILATION CONTROL'//
06680      &' *****'////)
06690      WRITE (6,2)
06700 2      FORMAT (' A LARGE SIZE MANUFACTURING FACILITY IN ',
06710      &' STILLWATER, OKLAHOMA IS LOCATED IN A '// WELL ',
06720      &' INSULATED METAL PREFABRICATED BUILDING. AFTER ',
06730      &' ANALYSIS OF PRESENT '// AIR CHANGES AND REQUIRED ',
06740      &' MAKE UP AIR CHANGES, THE COMPANY HAS DETERMINED ',
06750 Z      &' IT '// MAY REDUCED PRESENT VENTILATION REQUIREMENTS'//)
06760 700      WRITE (6,3)
06770 3      FORMAT(' DO YOU WISH TO RUN VENTILATION CONTROL? ',
06780      &' ENTER "1" - YES "0" - NO'//)
06790      READ (5,*) I
06800      IF (I.NE.1) RETURN
06810      WRITE (6,4)
06820 4      FORMAT (' DO YOU WISH TO SEE AN EXAMPLE? ',
06830      &' ENTER "1" - YES "0" - NO'//)
06840      READ (5,*) I
06850      IF (I.NE.0) GO TO 600
06860      WRITE (6,5)
06870 5      FORMAT(' ENTER DATA AS REQUESTED BY COMPUTER IF',
06880      &' NECESSARY',
06890      &' TO CHANGE'// IMPORTANT!!'// WHEN ENTERING DECIMAL VALUES',
06900      &' PLACE ZERO BEFORE THE DECIMAL POINT'//)
06910 100      WRITE (6,6) PACH,DACH
06920 6      FORMAT (' PRESENT MAKE UP AIR IS', F10.2,' CFM'//
06930      &' DESIRED MAKE UP AIR IS', F10.2,' CFM'//
06940      &' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO'//)
06950      READ (5,*) I
06960      IF (I.NE.1) GO TO 200
06970      READ (5,*) PACH,DACH
06980      WRITE (6,7) PACH,DACH
06990 7      FORMAT (2F10.2)
07000      WRITE (6,8)
07010 8      FORMAT (' CORRECT? ENTER "1" - YES "0" - NO'//)
07020      READ (5,*) I
07030      IF (I.NE.1) GO TO 100
07040 200      WRITE (6,9) HOTOT,HOTIN,COOLOT,COOLIN
07050 9      FORMAT (' AVERAGE HEATING SEASON OUTSIDE AIR TEMPERATURE',
07060      & F7.2// AVERAGE HEATING SEASON INDOOR AIR TEMPERATURE',
07070      & F7.2// AVERAGE COOLING SEASON OUTSIDE TEMPERATURE',F7.2/
07080      & ' AVERAGE COOLING SEASON INDOOR AIR TEMPERATURE',F7.2/
07090      & ' DO YOU WISH TO CHANGE? ENTER "1" - YES "0" - NO'//)
07100      READ (5,*) I
07110      IF (I.NE.1) GO TO 300
07120      READ (5,*) HOTOT,HOTIN,COOLOT,COOLIN
07130      WRITE (6,10) HOTOT,HOTIN,COOLOT,COOLIN
07140 10      FORMAT (4F7.2)
07150      WRITE (6,11)
07160 11      FORMAT (' CORRECT? ENTER "1" - YES "0" - NO'//)
07170      READ (5,*) I
07180      IF (I.NE.1) GO TO 200
07190 300      WRITE (6,12) FANHRA,FANHRB
07200 12      FORMAT (' AVERAGE FAN MOTOR HEATING OPERATING HOURS',F10.2/
07210      &' AVERAGE FAN MOTOR COOLING OPERATING HOURS',F10.2/

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07240      IF (I.NE.1) GO TO 400
07250      READ (5,*) FANHRA,FANHRB
07260      WRITE (6,13) FNAHRA,FANHRB
07270 13    FORMAT (2F10.2)
07280      WRITE (6,14)
07290 14    FORMAT (' CORRECT? ENTER "1" - YES "0" - NO'//)
07300      READ (5,*) I
07310      IF (I.NE.1) GO TO 300
07320 400    WRITE (6,15) BCOST
07330 15    FORMAT (' THE BTU COST OF ELECTRICITY IS APPROXIMATELY',
07340      &' $0.04/KWH * KWH/10000 BTU =' , F12.8// ' DO YOU WISH TO',
07350      &' CHANGE? ENTER "1" - YES "0" - NO'//)
07360      READ (5,*) I
07370      IF (I.NE.1) GO TO 500
07380      READ (5,*) BCOST
07390      WRITE (6,16) BCOST
07400 16    FORMAT (F10.8)
07410      WRITE (6,17)
07420 17    FORMAT (' CORRECT? ENTER "1" - YES "0" - NO'//)
07430      READ (5,*) I
07440      IF (I.NE.1) GO TO 400
07450 500    WRITE (6,18) FHP
07460 18    FORMAT (' FAN HORSEPOWER IS', F7.2// ' DO YOU WISH TO ',
07470      &' CHANGE? ENTER "1" - YES "0" - NO'//)
07480      READ (5,*) I
07490      IF (I.NE.1) GO TO 600
07500      READ (5,*) FHP
07510      WRITE (6,19) FHP
07520 19    FORMAT (F7.2)
07530      WRITE (6,20)
07540 20    FORMAT (' CORRECT? ENTER "1" - YES "0" - NO'//)
07550      READ (5,*) I
07560      IF (I.NE.1) GO TO 500
07570 600    CONTINUE
07580      HVENT=1.08*PACH*(HOTIN-HOTOT)*BCOST*FANHRA
07590      HVSAB=1.08*(PACH-DACH)*(HOTIN-HOTOT)*BCOST*FANHRA
07600      CVENT=1.08*PACH*(COOLOT-COOLIN)*BCOST*FANHRB
07610      CVSAB=1.08*(PACH-DACH)*(COOLOT-COOLIN)*BCOST*FANHRB
07620      FANCT=FHP*7460*BCOST*(FANHRA+FANHRB)
07630      FANSV=FANCT-(((1-DACH/PACH)**3)*FHP*7460*BCOST*(FANHRA+FANHRB
)
07640      HPSAV=FHP-(((1-DACH/PACH)**3)*FHP
07650      WRITE (6,21) PACH,DACH,HOTOT,HOTIN,COOLOT,COOLIN,FANHRA,
07660      & FANHRB,FHP,BCOST
07670 21    FORMAT (' THE PRESENT MAKE UP AIR VOLUME IS',F10.2,' CFM'//
07680      & ' THE DESIRED MAKE UP AIR VOLUME IS',F10.2,' CFM'//
07690      & ' THE AVERAGE OUTDOOR HEATING SEASON TEMPERATURE IS',
07700      & F7.2,' F'//
07710      & ' THE AVERAGE INDOOR HEATING SEASON TEMPERATURE IS',
07720      & F7.2,' F'//
07730      & ' THE AVERAGE OUTDOOR COOLING SEASON TEMPERATURE IS',
07740      & F7.2,' F'//
07750      & ' THE AVERAGE INDOOR COOLING SEASON TEMPERATURE IS',
07760      & F7.2,' F'//
07770      & ' THE APPROXIMATE FAN OPERATING HOURS PER HEATING ',
07780      & ' SEASON IS', F10.2,' HOURS'//
07790      & ' THE APPROXIMATE FAN OPERATING HOURS PER COOLING ',
07800      & ' SEASON IS', F10.2,' HOURS'//
07810      & ' THE APPROXIMATE PRESENT FAN HORSEPOWER IS',F7.2,' HP'//
07820      & ' THE APPROXIMATE COST OF ELECTRICITY IS',F12.8,
07830      & ' PER BTU'//)
07840      WRITE (6,22) HVENT,HVSAB,CVENT,CVSAB,FANCT,FANSV,HPSAV
07850 22    FORMAT (' THE HEATING SEASON VENTILATION COST IS $',F7.2/
07860      & ' THE POTENTIAL SAVINGS ARE $',F7.2//

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07890 & ' THE FAN OPERATING COST IS \$ ',F7.2,' PER YEAR'//
07900 & ' THE POTENTIAL SAVINGS ARE \$',F7.2/
07910 & ' THE REDUCTION OF HORSEPOWER POSSIBLE IS ',F7.2/
07920 & ' IF YOU HAVE ANY QUESTIONS SEE MANUAL PAGE .'/\\\\\\//
07930 GO TO 700
07940 END
READY
1